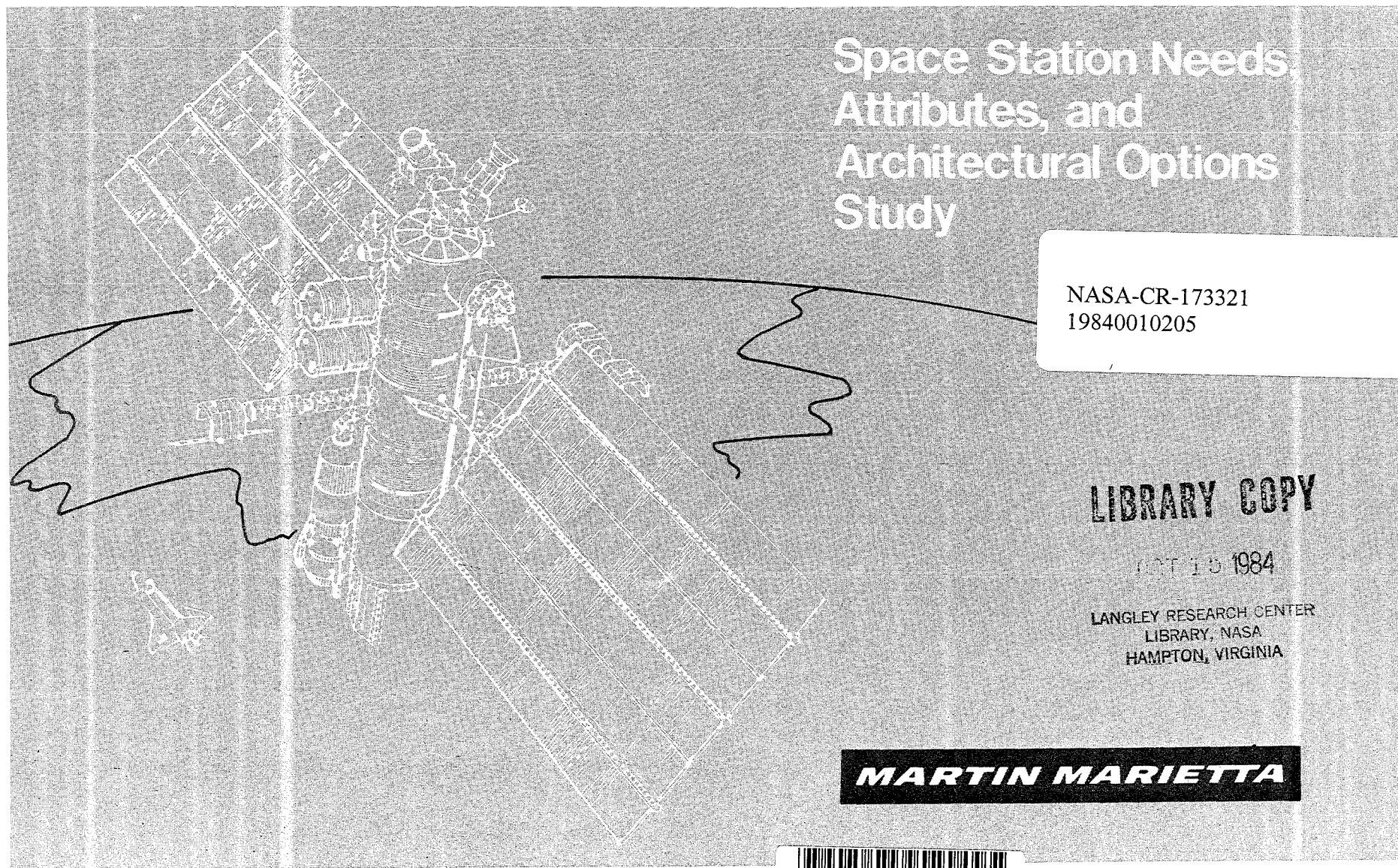


SOC-SE-02-02
Contract NASW-3686

NASA CR-173,321

Final Review/Executive Summary

April 1983



Space Station Needs, Attributes, and Architectural Options Study

NASA-CR-173321
19840010205

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NF01459

NASA

National Aeronautics and
Space Administration

FOREWORD

This document is submitted in accordance with the requirements of Contract NASW-3686, Schedule Article II, and Contractor Task 5.3 of Attachment A Statement of Work. This document is the briefing material for the final review.

N84-18273 #

Contract NASW-3686

April 1983

SPACE STATION NEEDS
ATTRIBUTES AND
ARCHITECTURAL OPTIONS

BRIEFING MATERIAL
FINAL REVIEW

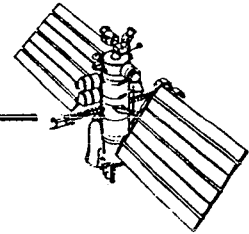
Prepared For:

The National Aeronautics
and Space Administration (NASA)
and The Department of Defense (DOD)

Prepared By:

Martin Marietta Aerospace
Denver Aerospace
Space and Electronics Systems Division
P. O. Box 179
Denver, CO 80201

Program Manager: Sherman R. Schrock



Summary Results

Space Station Needs, Attributes

And

Architectural Options

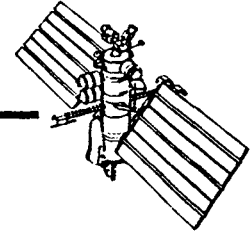
Study

APRIL 5, 1983

1

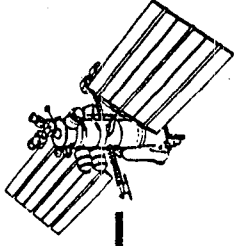
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Summary Results



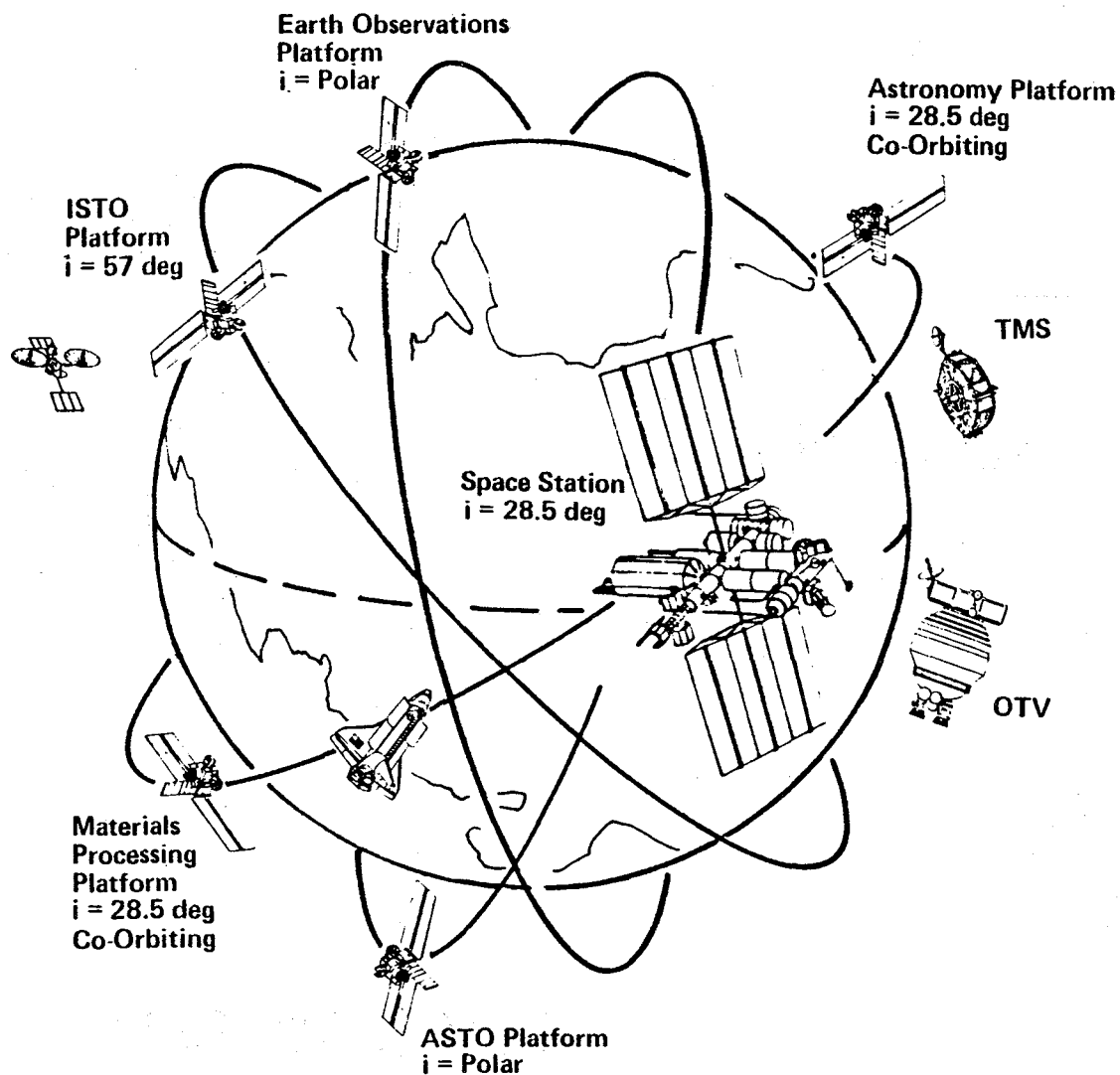
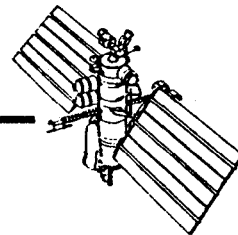
Agenda

- Introduction
- Time Phased Mission Requirements & Attributes
- Program Evolution
- Space Station Architecture
- Key Technologies
- Associated Cost and Benefits
- Conclusions



Introduction

Space Station System Architecture

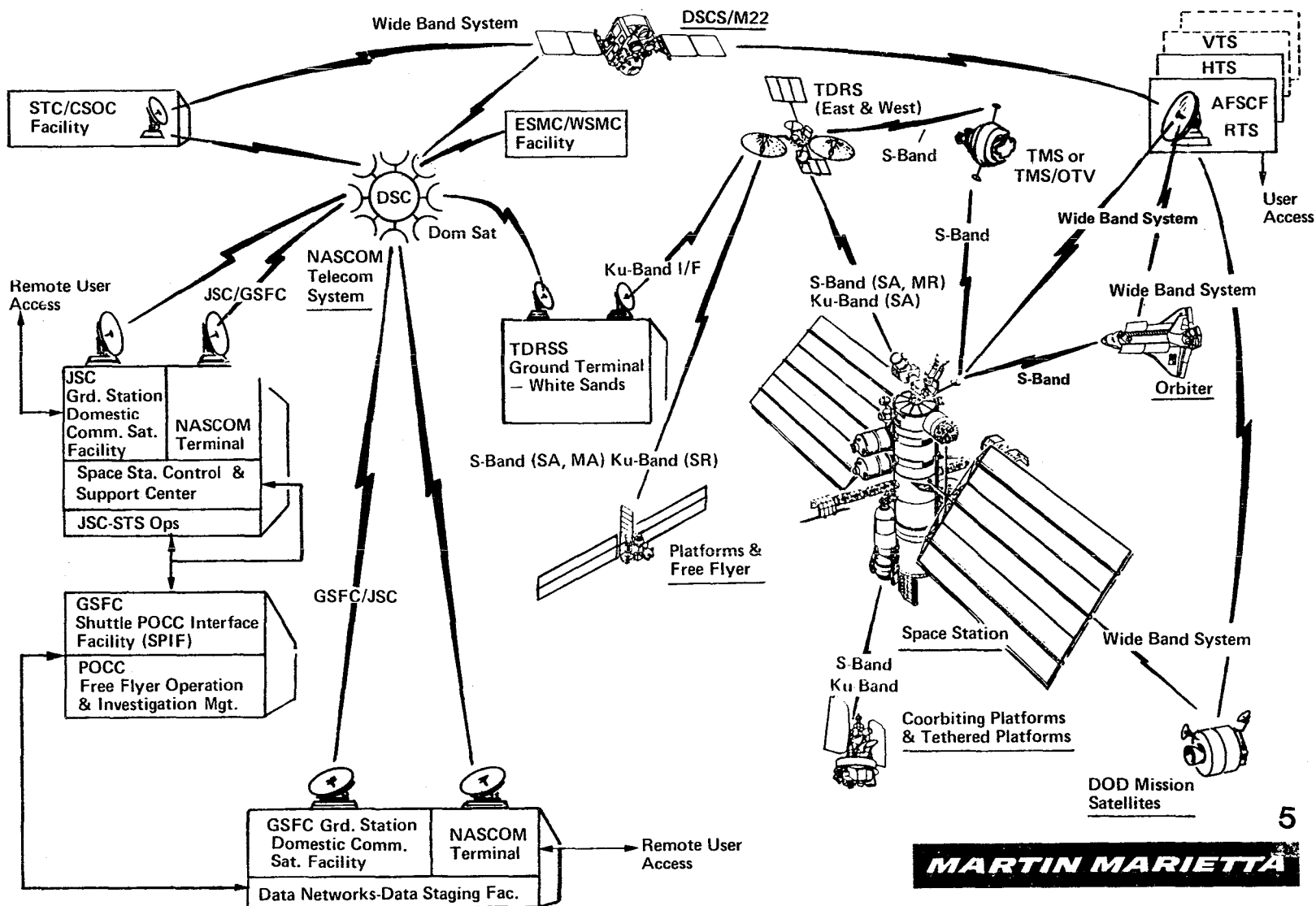


Location	Qty	Element
28.5 deg	1	Station
SS	2	OTV
SS	2	TMS/Serviceers
28.5 deg	1	ASTR Platform
Polar	1	EO Platform
57 deg	1	ISTO Platform
28.5 deg	1-2	MP Platform
Polar	1	ASTO Platform

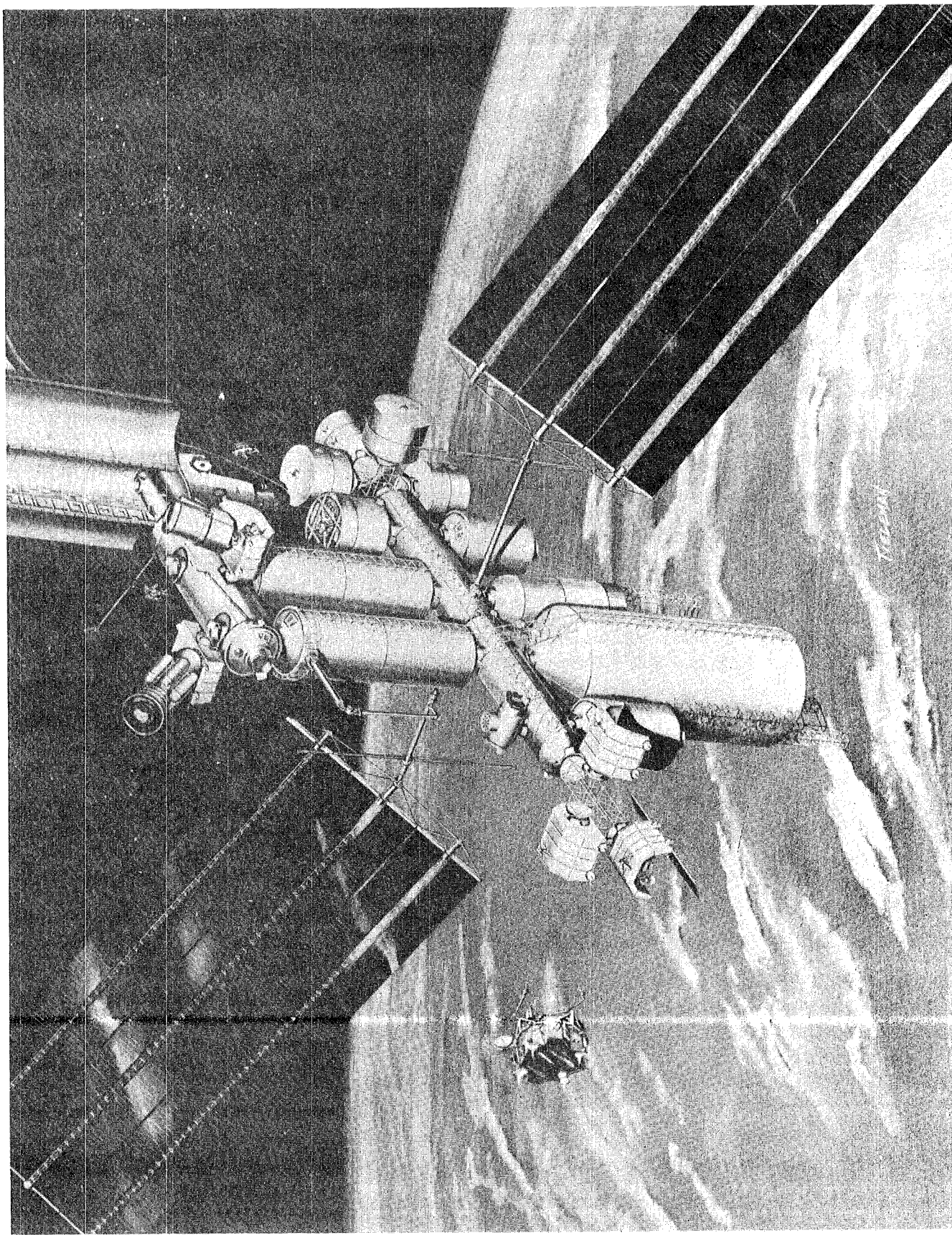
Functional Capabilities:

- Orbital Transfer/Retrieval
- Satellite Servicing
- Assembly
- Operational Services

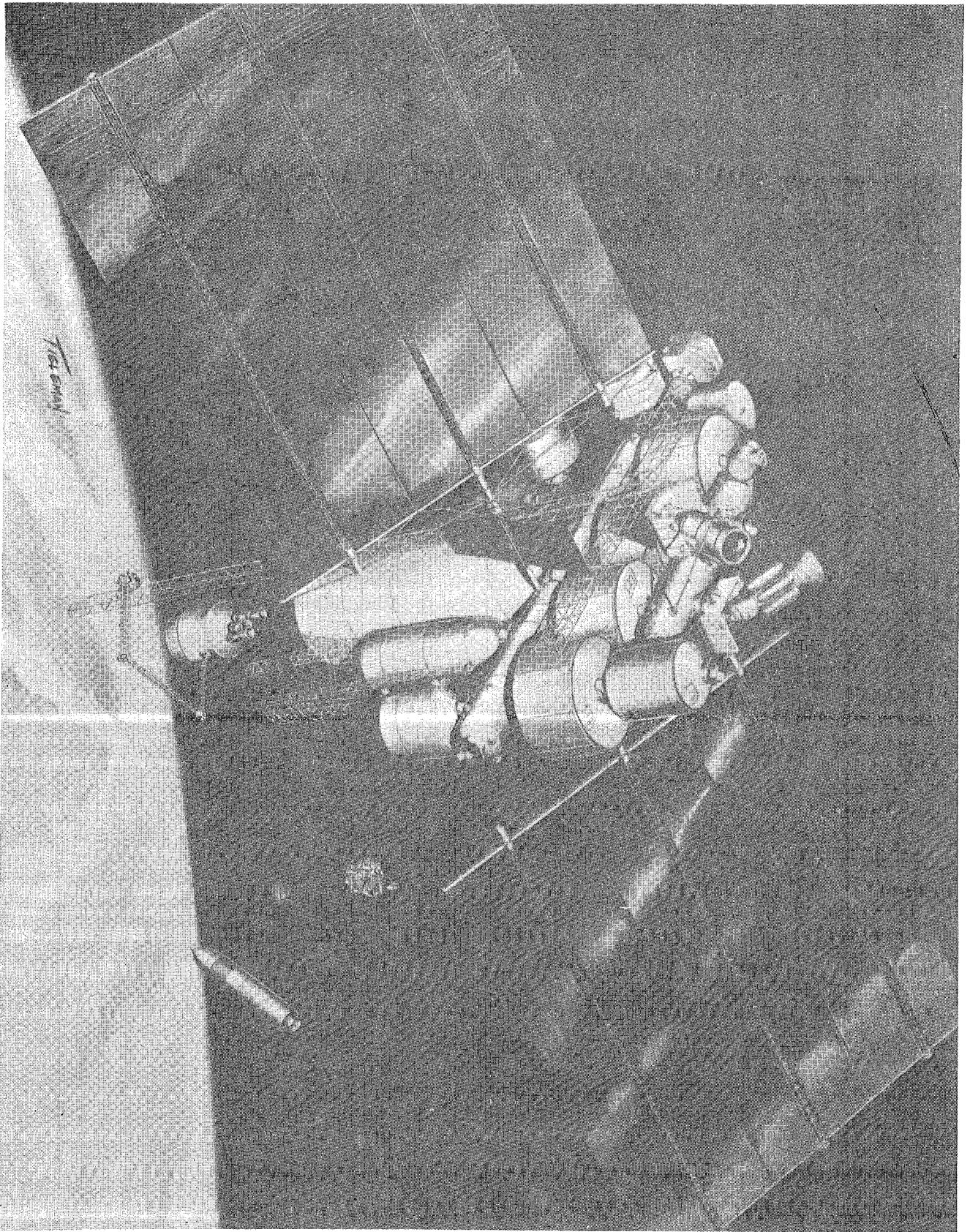
Space Station Operations Architecture / Infrastructure



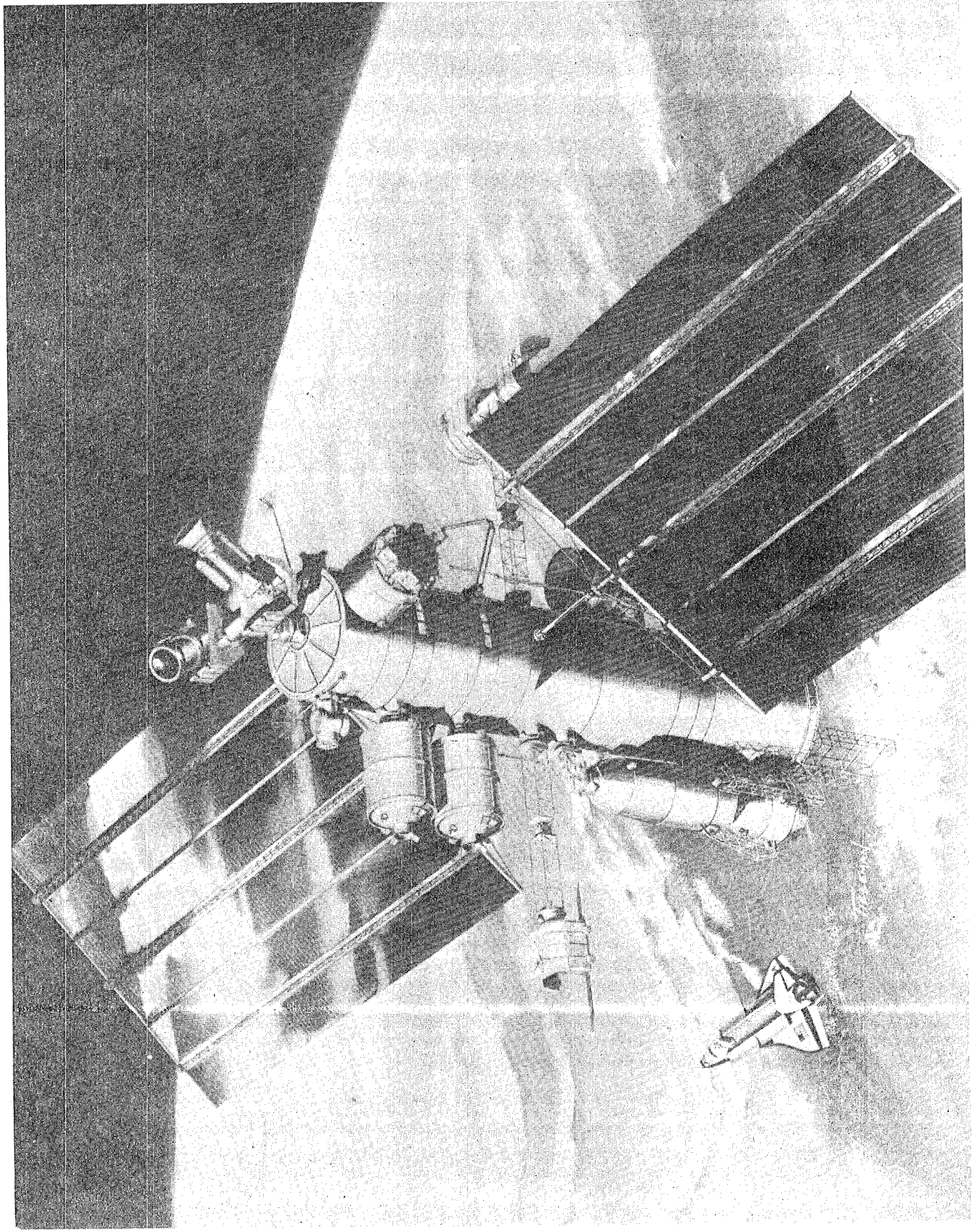
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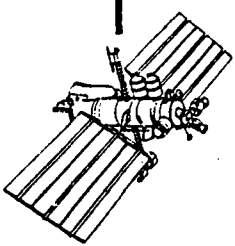
MODULAR CARGO BAY CONCEPT SPACE STATION



AFT CARGO CARRIER CONCEPT SPACE STATION

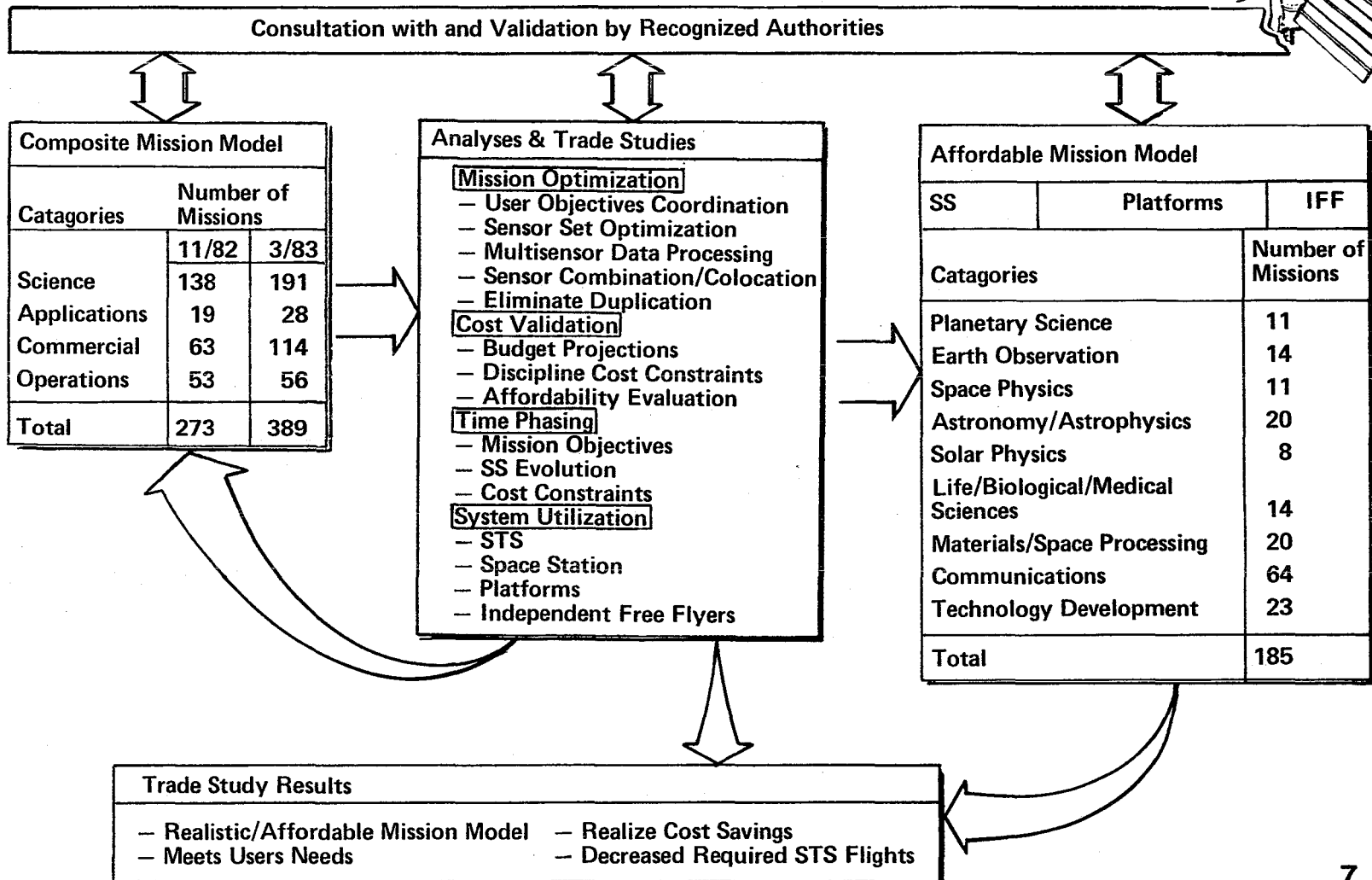
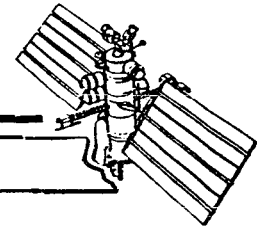


SHUTTLE DERIVED VEHICLE SPACE STATION

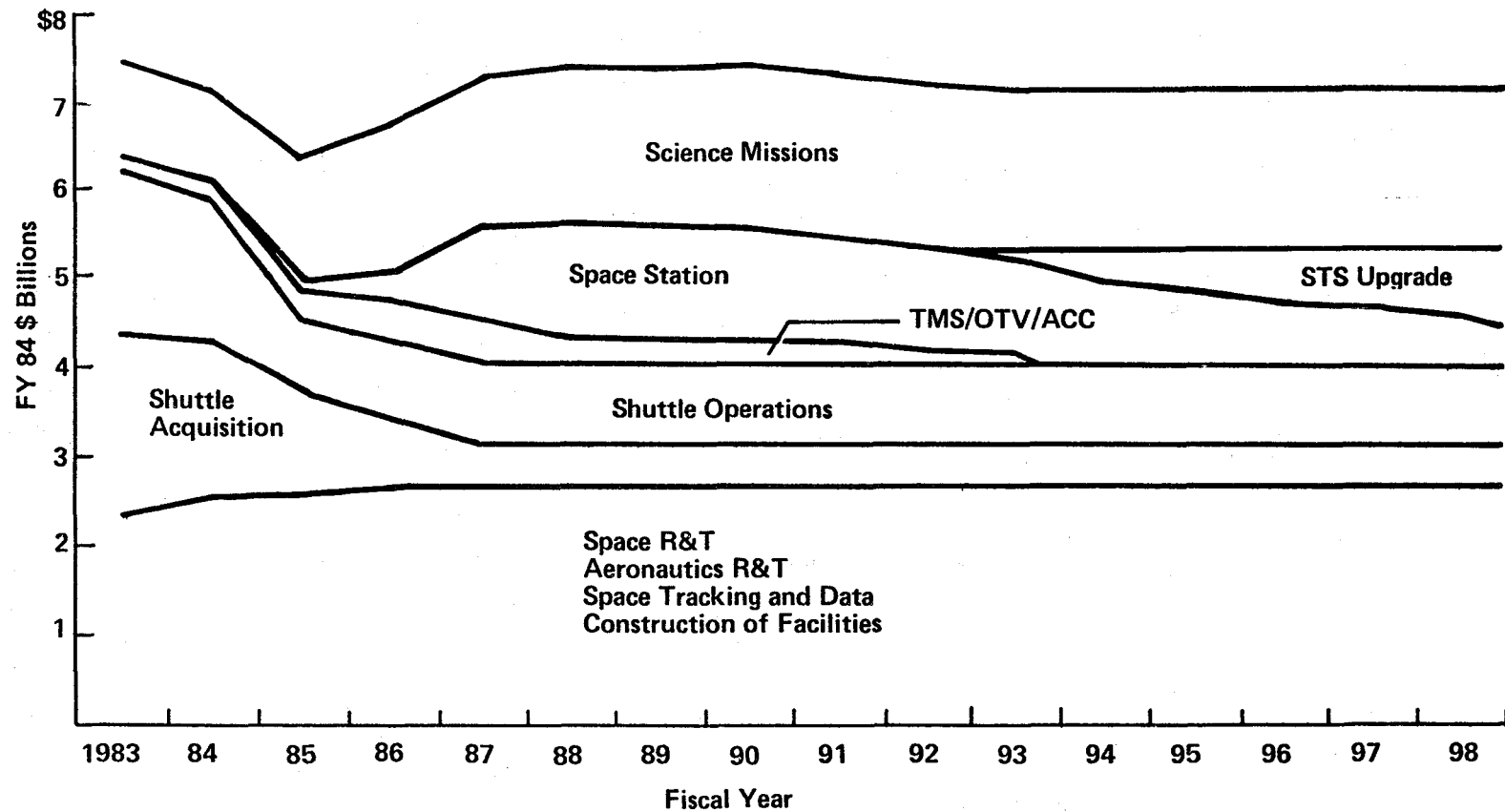
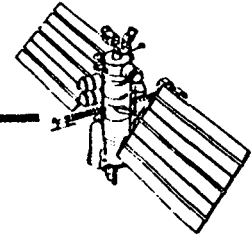


Time Phased Mission Requirements & Attributes

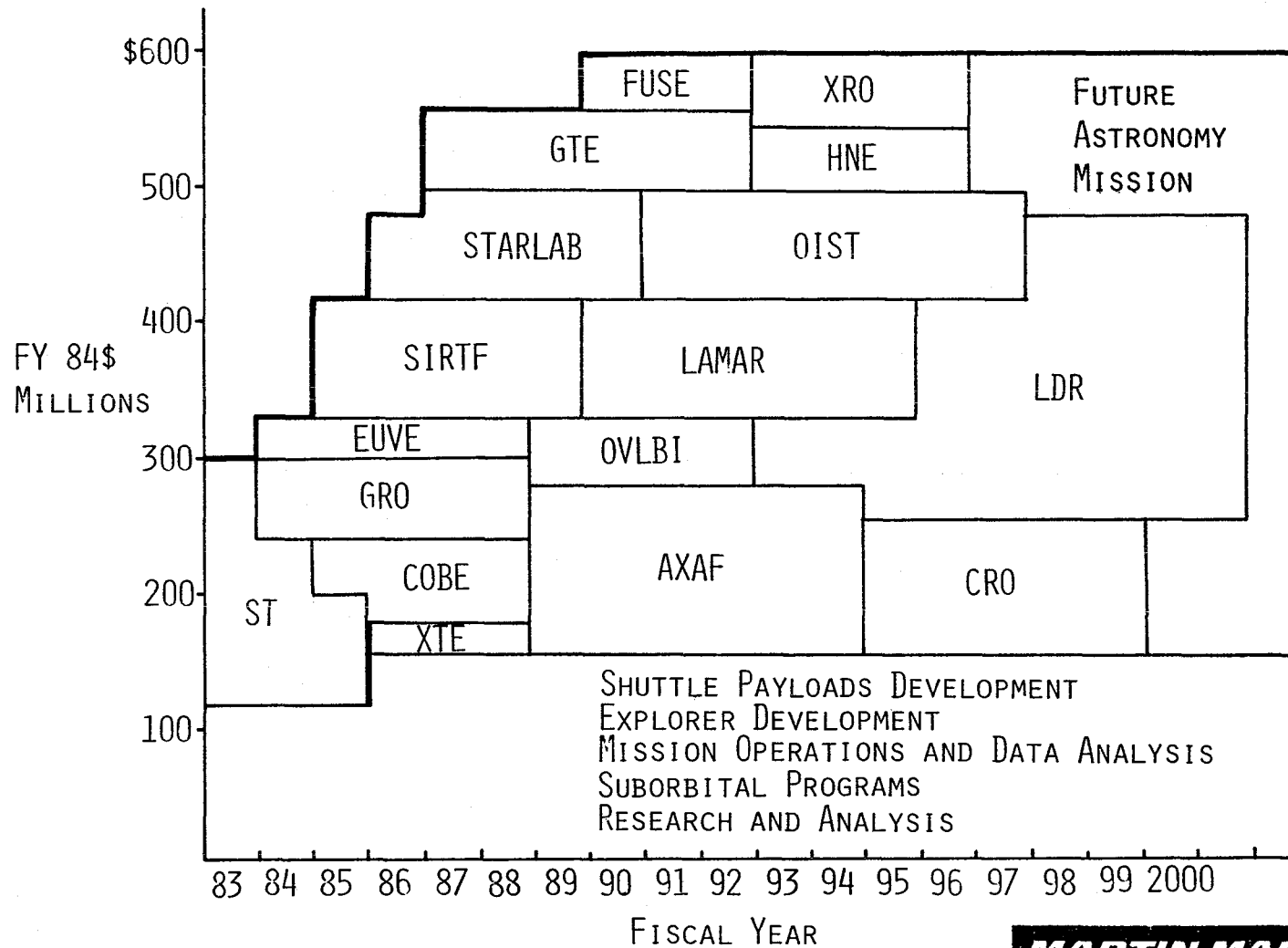
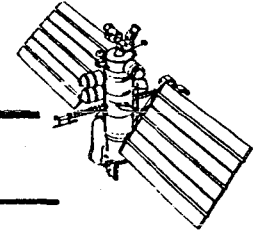
Affordable Mission Model Development



NASA Budget Projection – Affordability Analysis

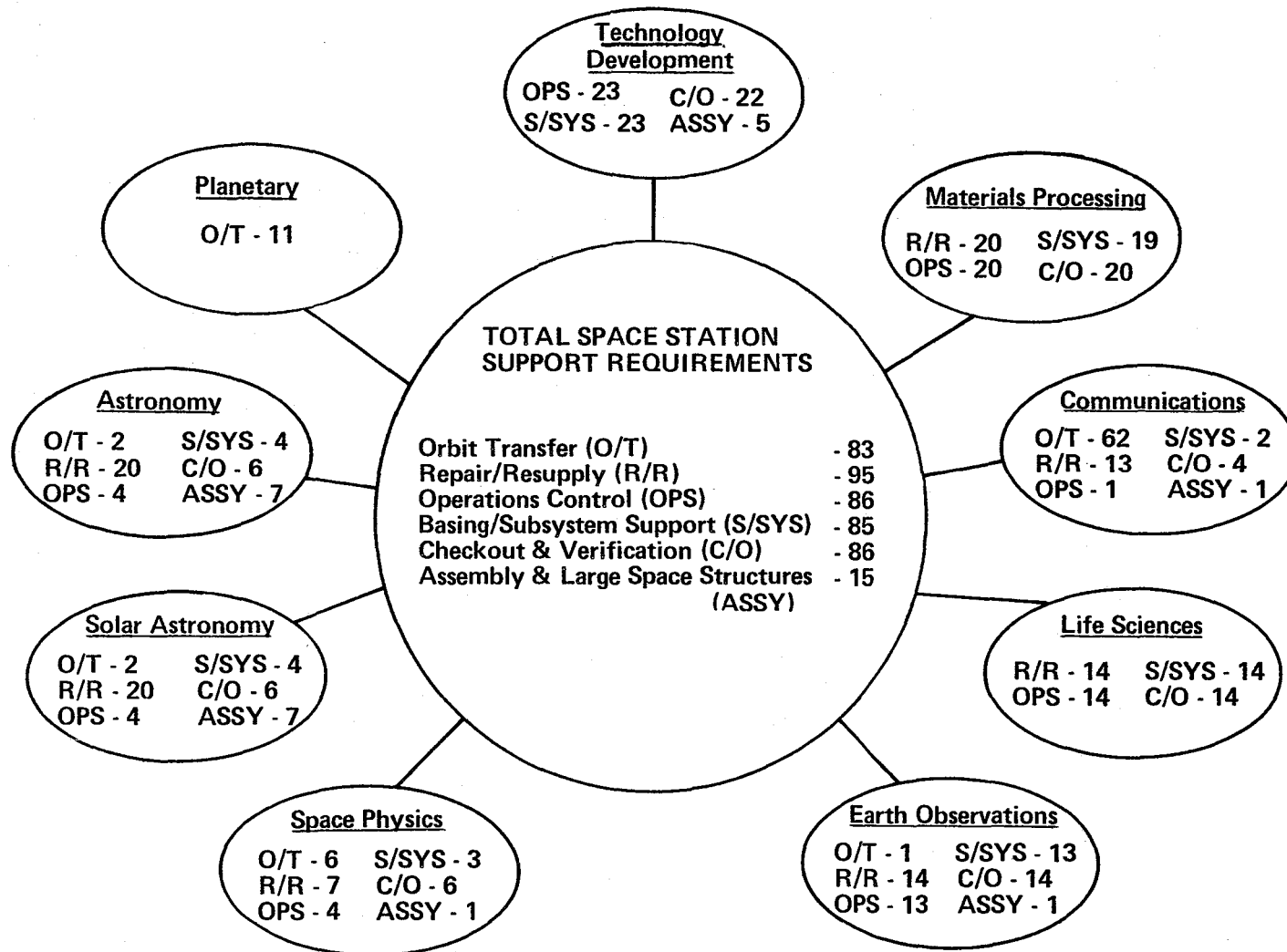
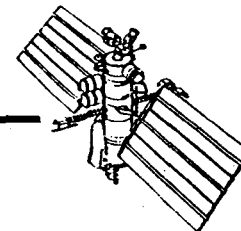


Astronomy Affordability Analysis

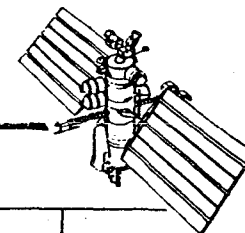


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User Functional Support Requirements



Mission Accommodation Allocation-28.5° Option

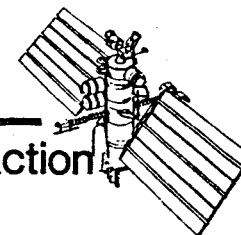


CATEGORY	ORBIT TRANSFER/ SUPPORT	SPACE STATION	PLATFORMS					TOTAL
			EARTH OBS	ISTO	ASTO	MAT PROC	ASTRONOMY	
PLANETARY	11	-	-	-	-	-	-	11
EARTH OBS	4	4(T→P)	6	-	-	-	-	14
SPACE PHYSICS	6	1	-	2	2	-	-	11
ASTRONOMY	15	2(T→P)	-	-	-	-	3	20
SOLAR ASTRONOMY	2	-	-	-	-	-	6	8
LIFE SCIENCES	-	14	-	-	-	-	-	14
MATERIAL PROC.	6	4	-	-	-	10	-	20
COMMUNICATIONS	63	1	-	-	-	-	-	64
TECHNOLOGY DEVELOP.	-	23	-	-	-	-	-	23
	107	49	6	2	2	10	9	185

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Operations Concept

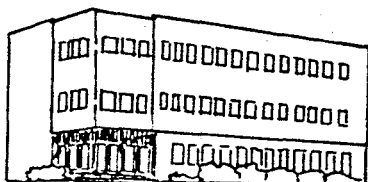
No Change to Space Element Infrastructure Interaction



SPACE STATION

- Operations Control
 - Onboard Crew Takes More Responsibility
- Telepresence Control
- Operations Centers (Master & Backups)
 - Plan Onboard Activities and Manning Requirements.

GROUND OPERATIONS

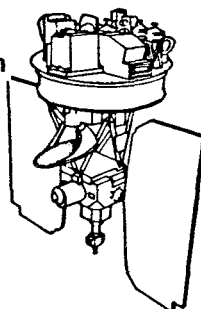


New Approach to Ground Support

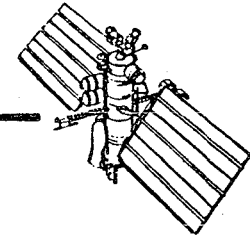
- Initial Build-up & Activation
 - Business As Usual
- Decreasing Levels of Manning during Evolution
 - Rely More on Flight Crew
- Final Station Configuration & Operations
 - Relay Heavily on Flight Crew
 - Critical Parameter Monitoring
 - On Call Technical Support

PLATFORMS & SATELLITES

- Coorbiting Platforms (Space Station Control)
- Free Flying Platforms & Satellites (Ground Control)



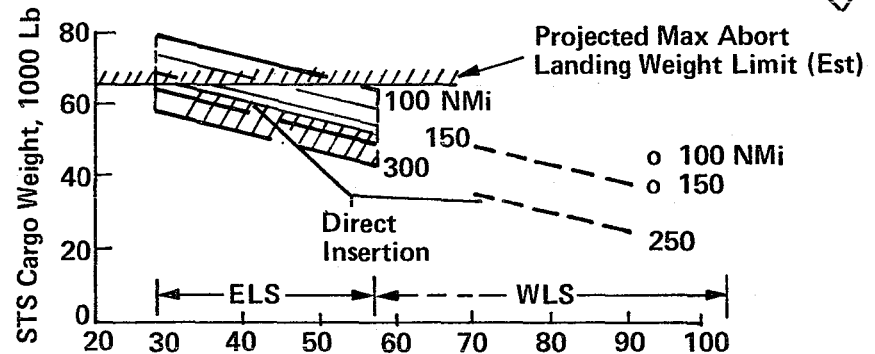
Mission Analysis Trades Summary



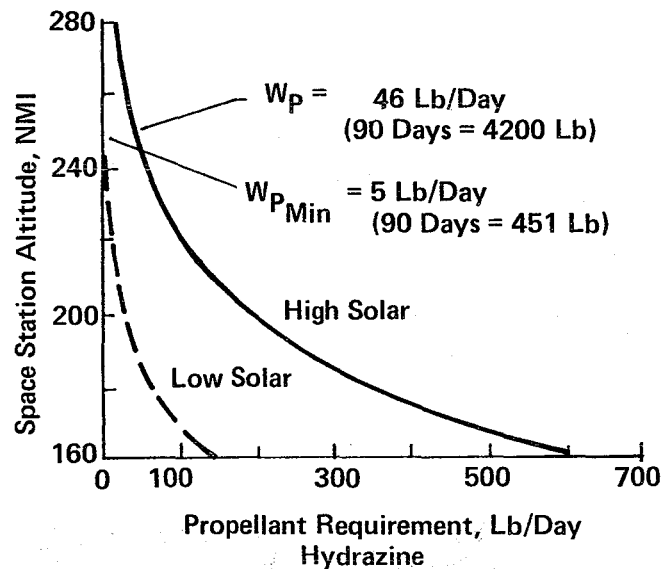
Summary

- o Launch Site - ELS
- o STS Selected Orbit Altitude - 250 NMi
- o Recommended SS Orbit Incl. - 28.5 deg

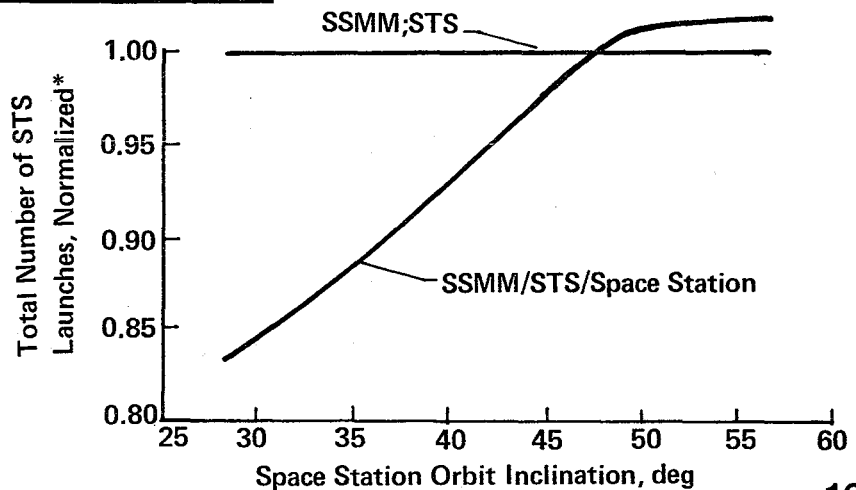
Location = ELS



Altitude = 250 NMi



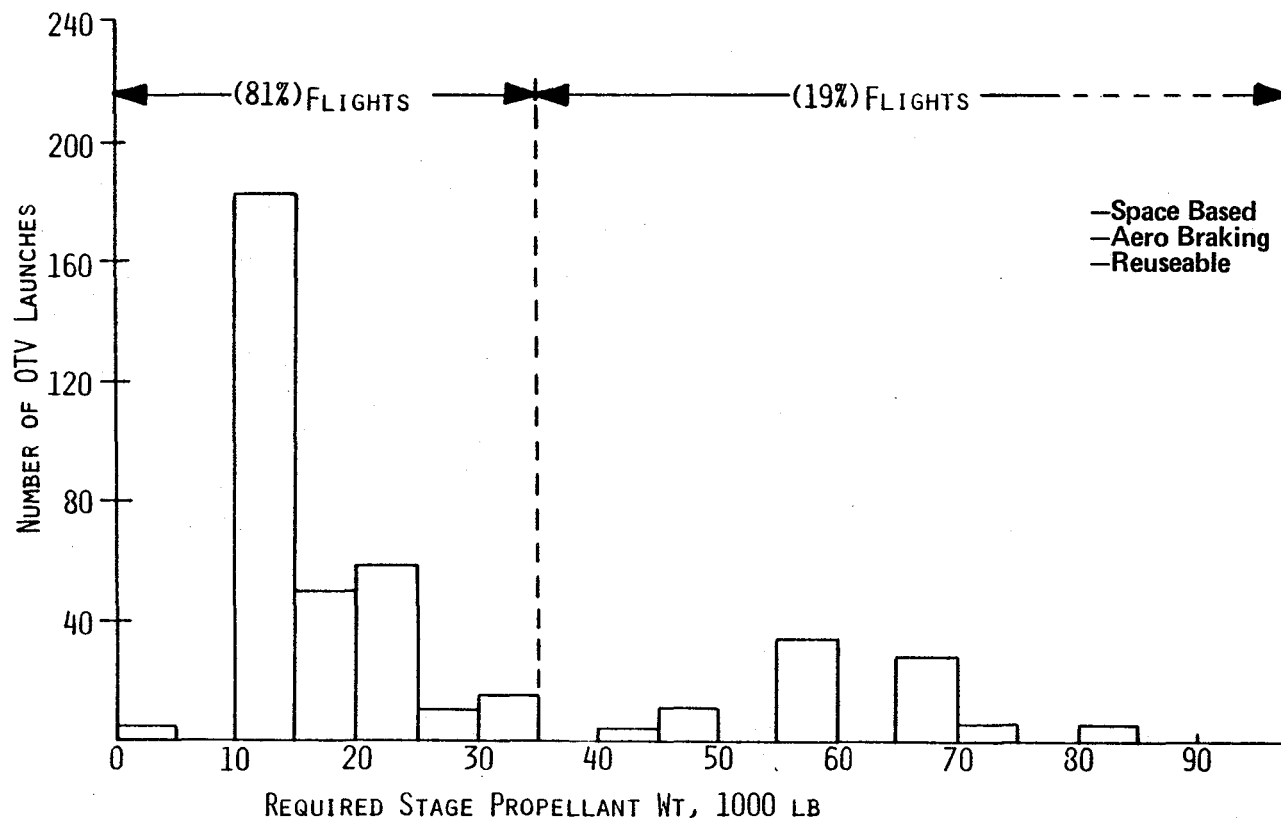
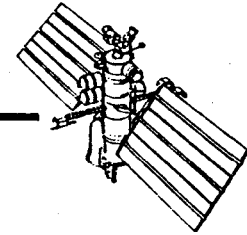
Inclination = 28.5 deg

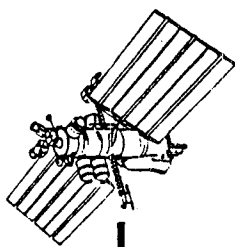


13

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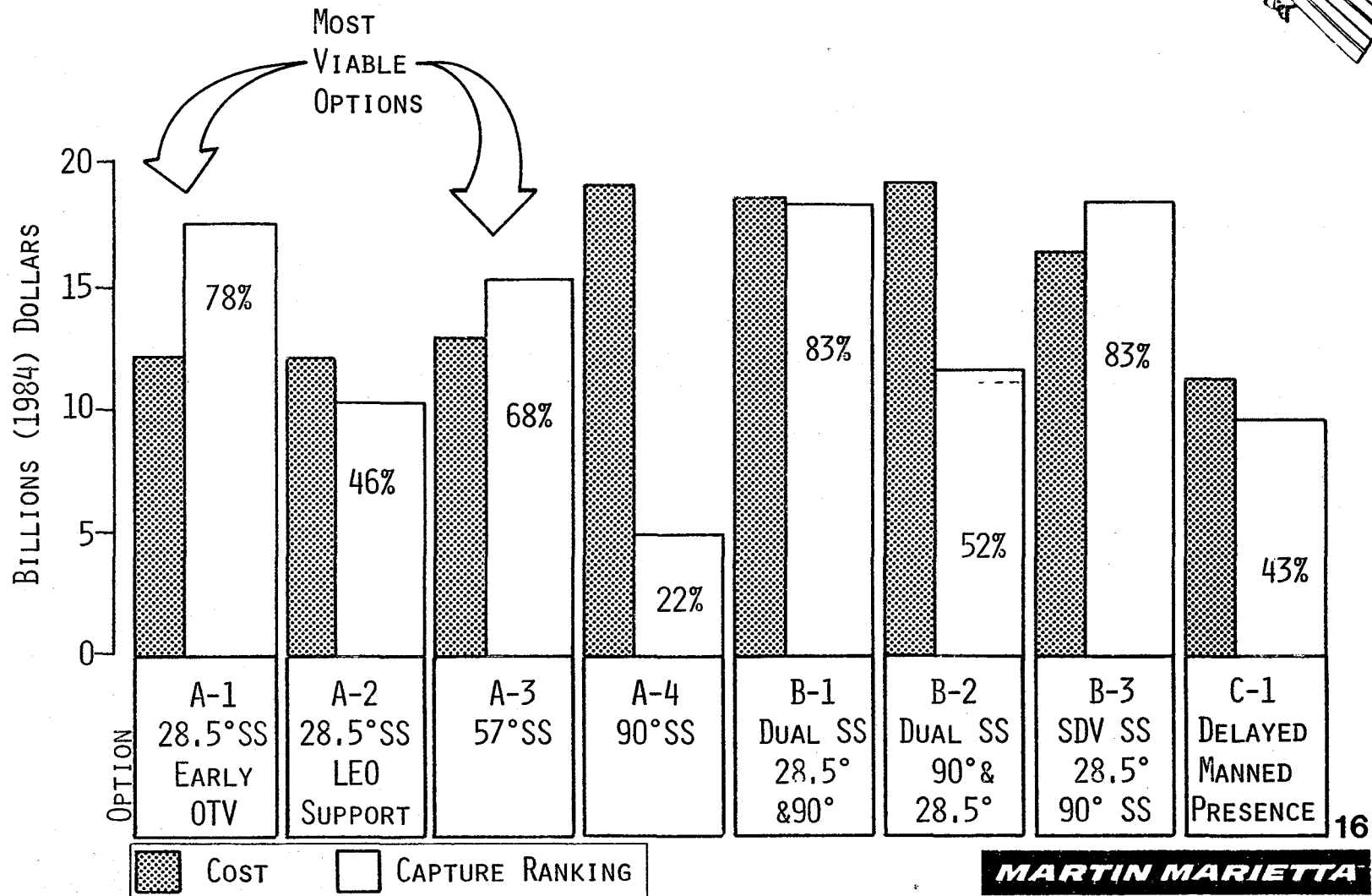
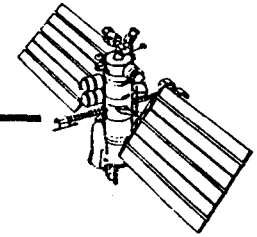
OTV Characterization Study





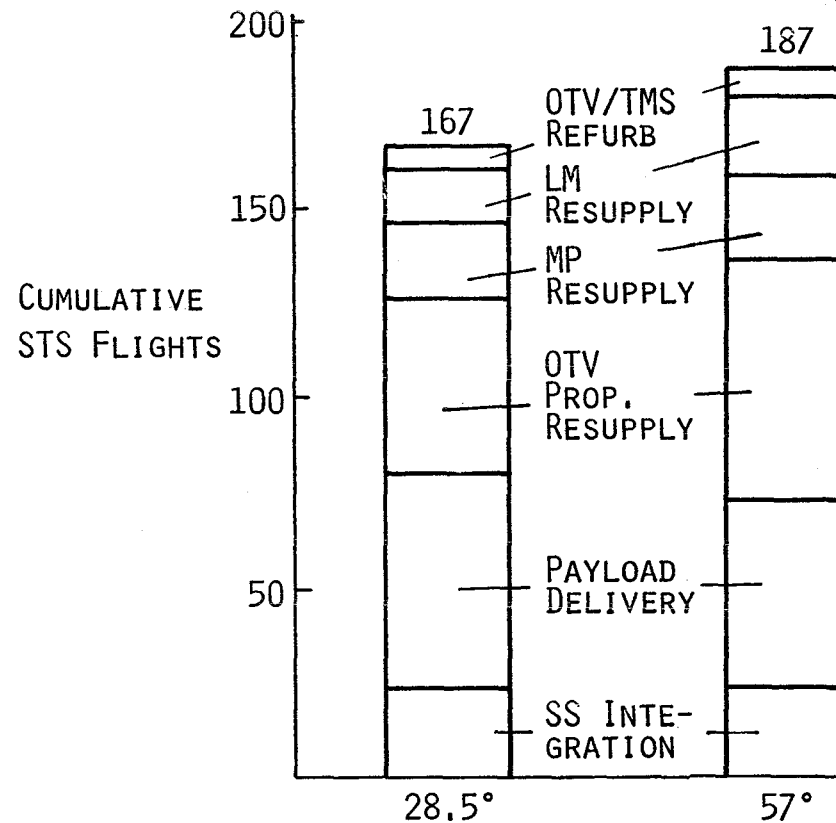
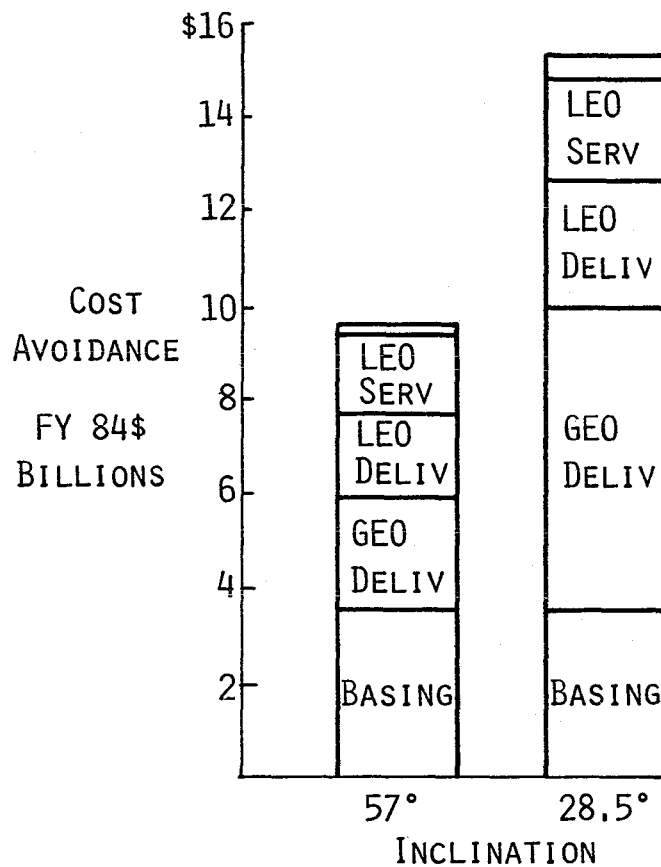
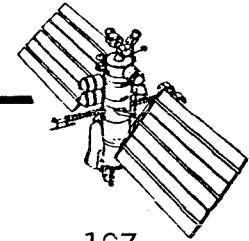
Program Evolution

Program Option Selection



Economic Benefits & STS Support

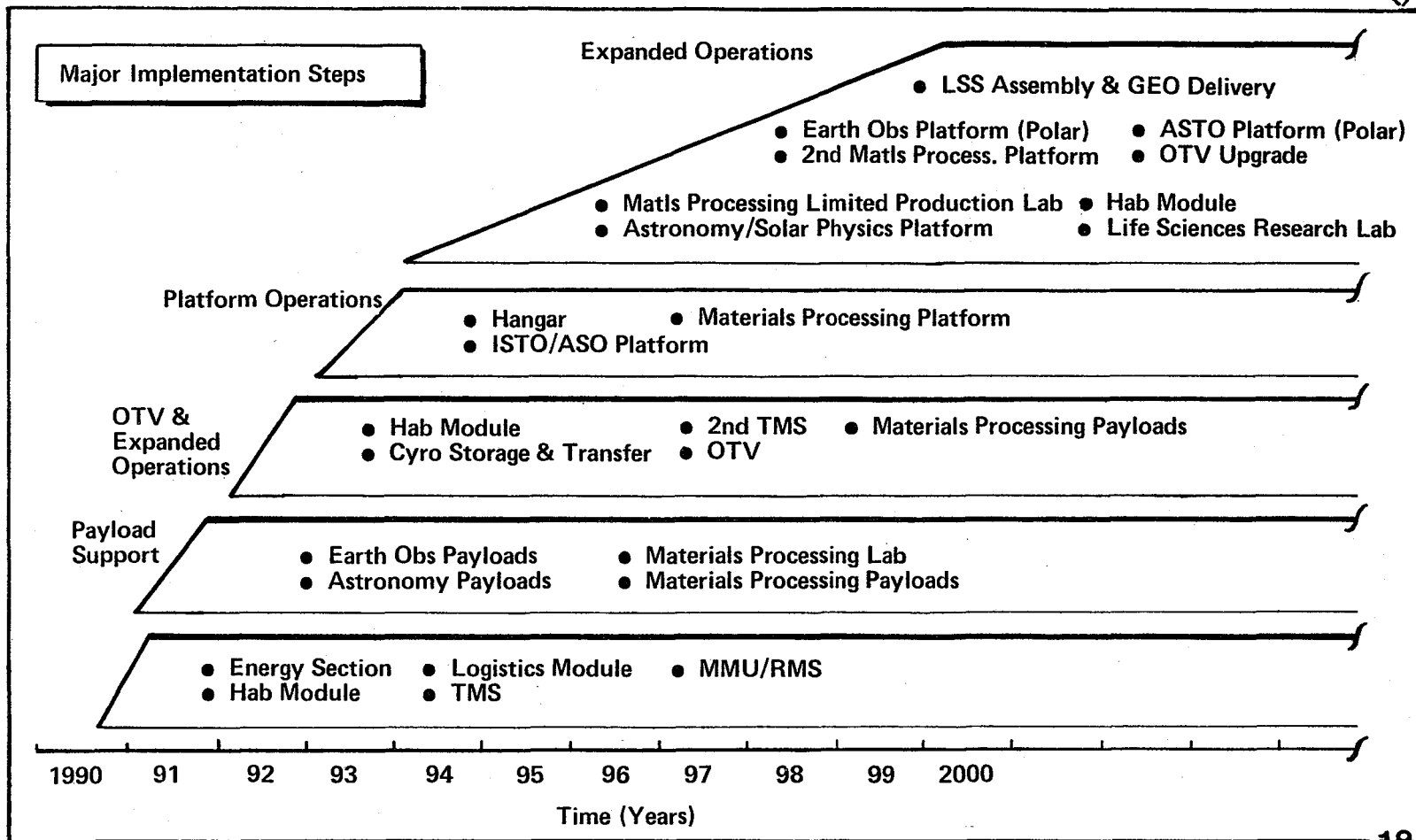
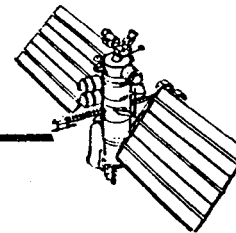
Comparison of A-1 & A-3 Options



ECONOMIC BENEFITS
AND STS FLIGHTS
SHOWN ARE CUMULATIVE
FOR 10 YEARS OF OPERATION

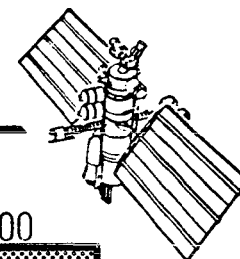
Recommended Evolution Plan

28.5° Space Station



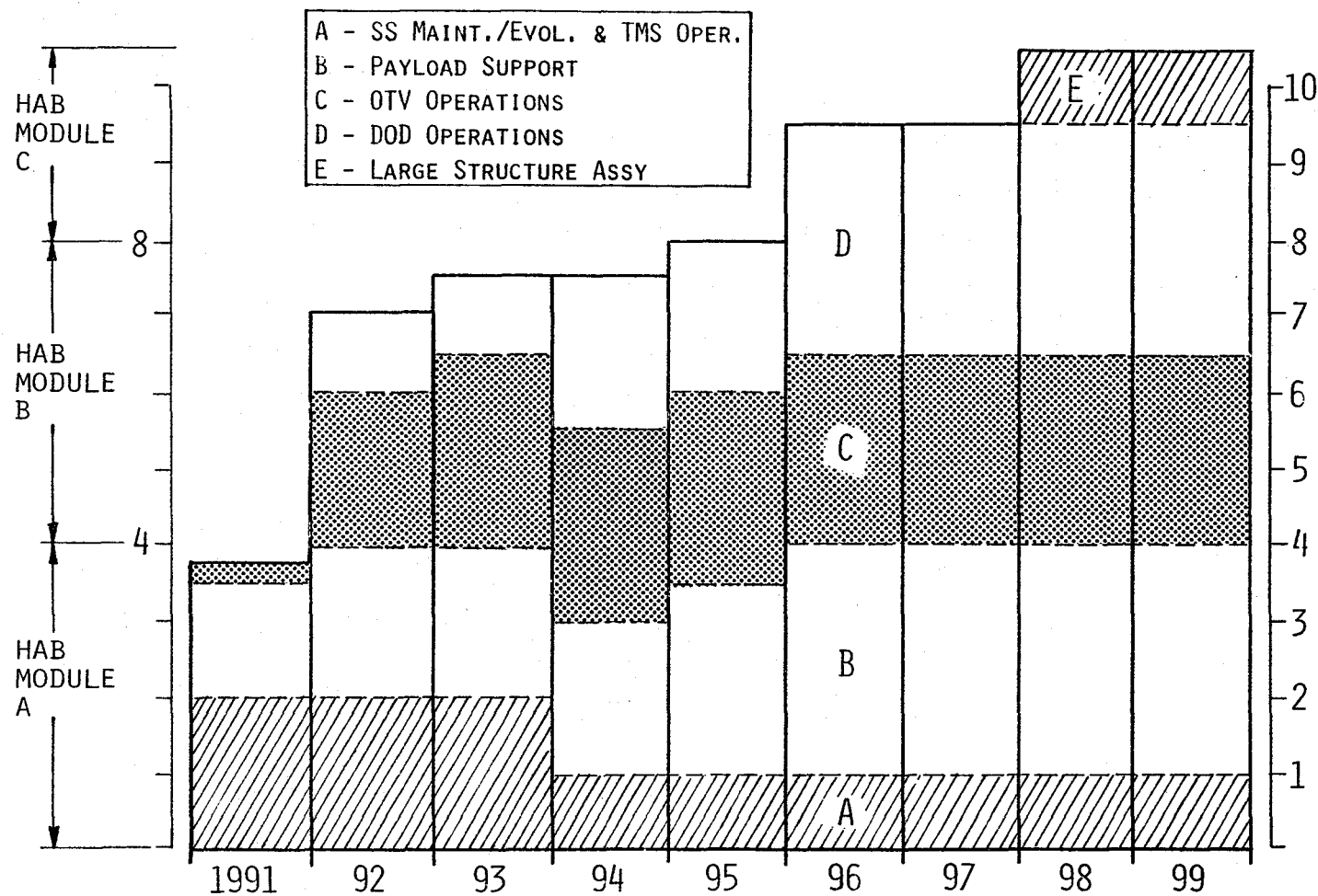
MARTIN MARIETTA

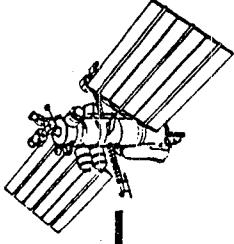
User Support Matrix



DISCIPLINE	91	92	93	94	95	96	97	98-2000
COMMERCIAL COMM. SAT								
MATL. PROC.								
ASTRONOMY								
EARTH OBSERVATIONS						PAYLOADS TRANSFERRED TO EO PLATFORM		
SPACE PHYSICS								
SOLAR PHYSICS								
LIFE SCIENCES								

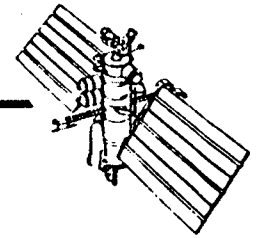
Crew Activities & Sizing





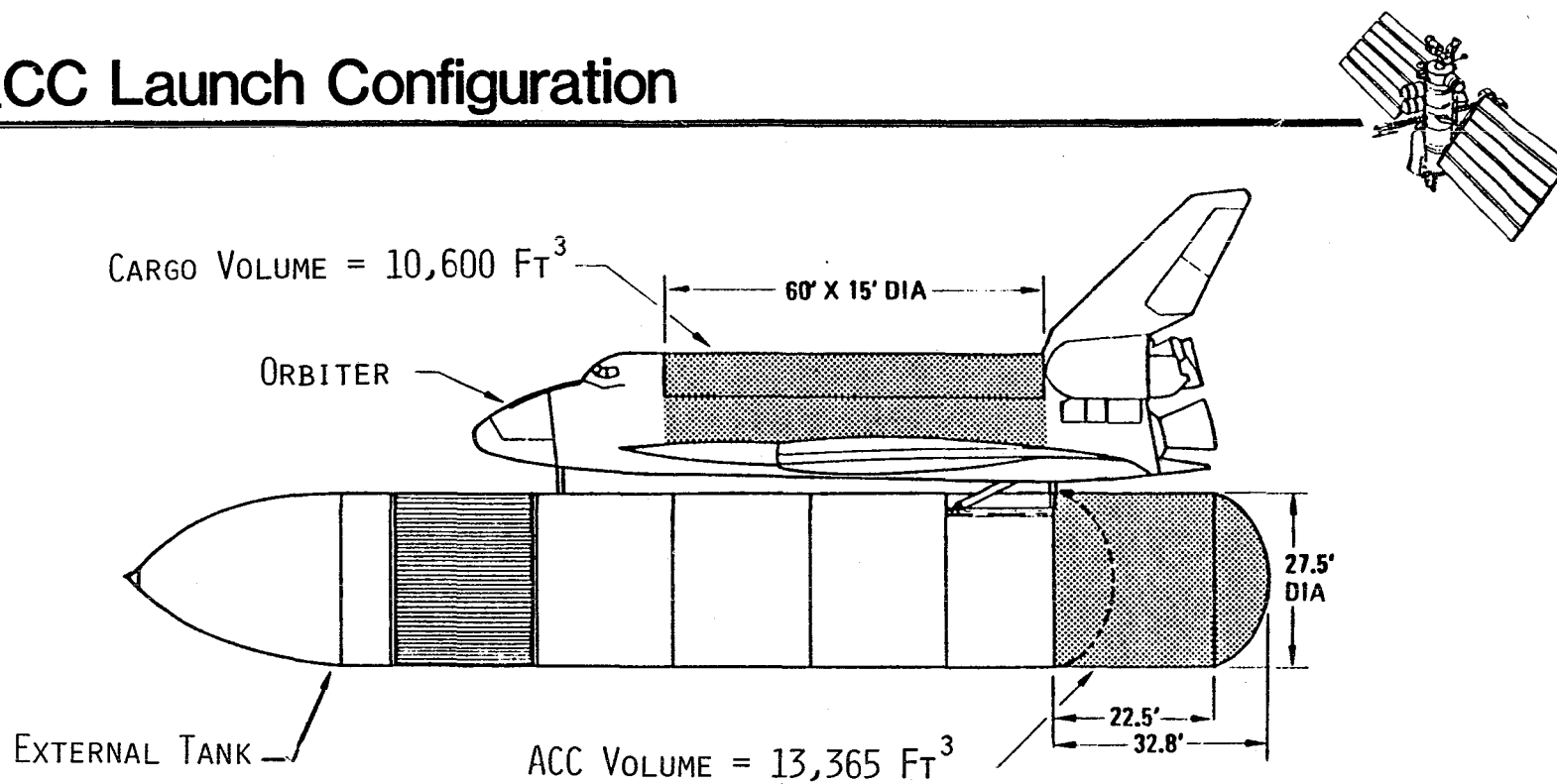
Space Station Architecture

Architectural/Configuration Options

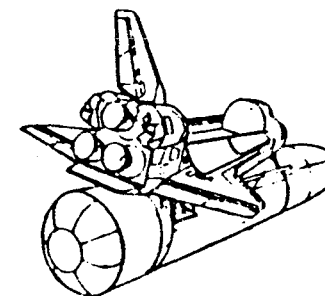


OPTION	PRESS. VOLUME	STS FLIGHTS	ADVANTAGES	DISADVANTAGES
MODULAR 14' DIA.	23,700 FT ³	12	<ul style="list-style-type: none"> ● MODULE COMMONALITY ● FAVORABLE MASS PROPERTIES 	<ul style="list-style-type: none"> ● COMPLEX BUILD-UP ● ARRAY SHADOWING
MODULAR AFT CARGO CARRIER	30,500 FT ³	10	<ul style="list-style-type: none"> ● UTILIZES AFT CARGO CARRIER (ACC) VOLUME 	<ul style="list-style-type: none"> ● COMPLEX BUILD-UP
SHUTTLE DERIVED VEHICLE	33,000 FT ³	8	<ul style="list-style-type: none"> ● REDUCED ORBITAL BUILD-UP ● CREW SAFETY & COMFORT 	<ul style="list-style-type: none"> ● DEVELOPMENT COSTS

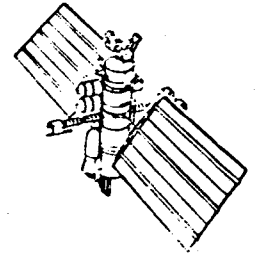
ACC Launch Configuration



- o PROVIDES AN INCREASE IN PAYLOAD DIAMETER
- o PROVIDES ADDITIONAL VOLUME
- o REDUCES CONSTRAINTS ON PAYLOAD BAY LIMITATIONS

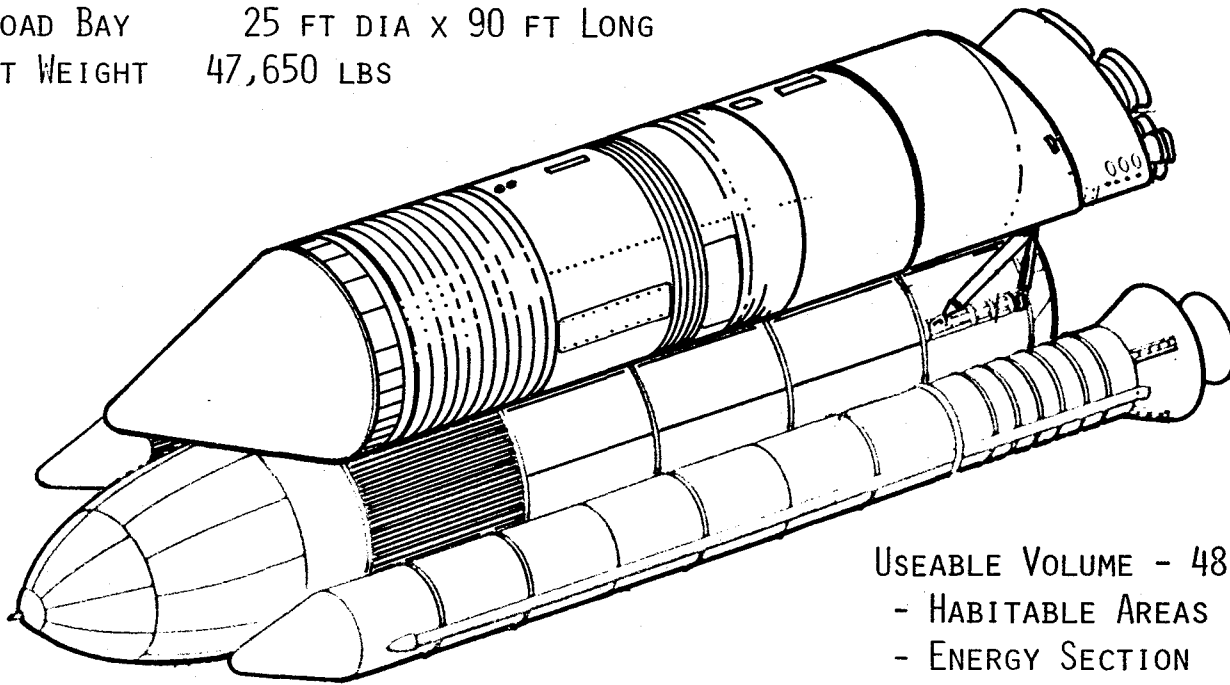


SDV Launch Configuration



PAYLOAD MODULE

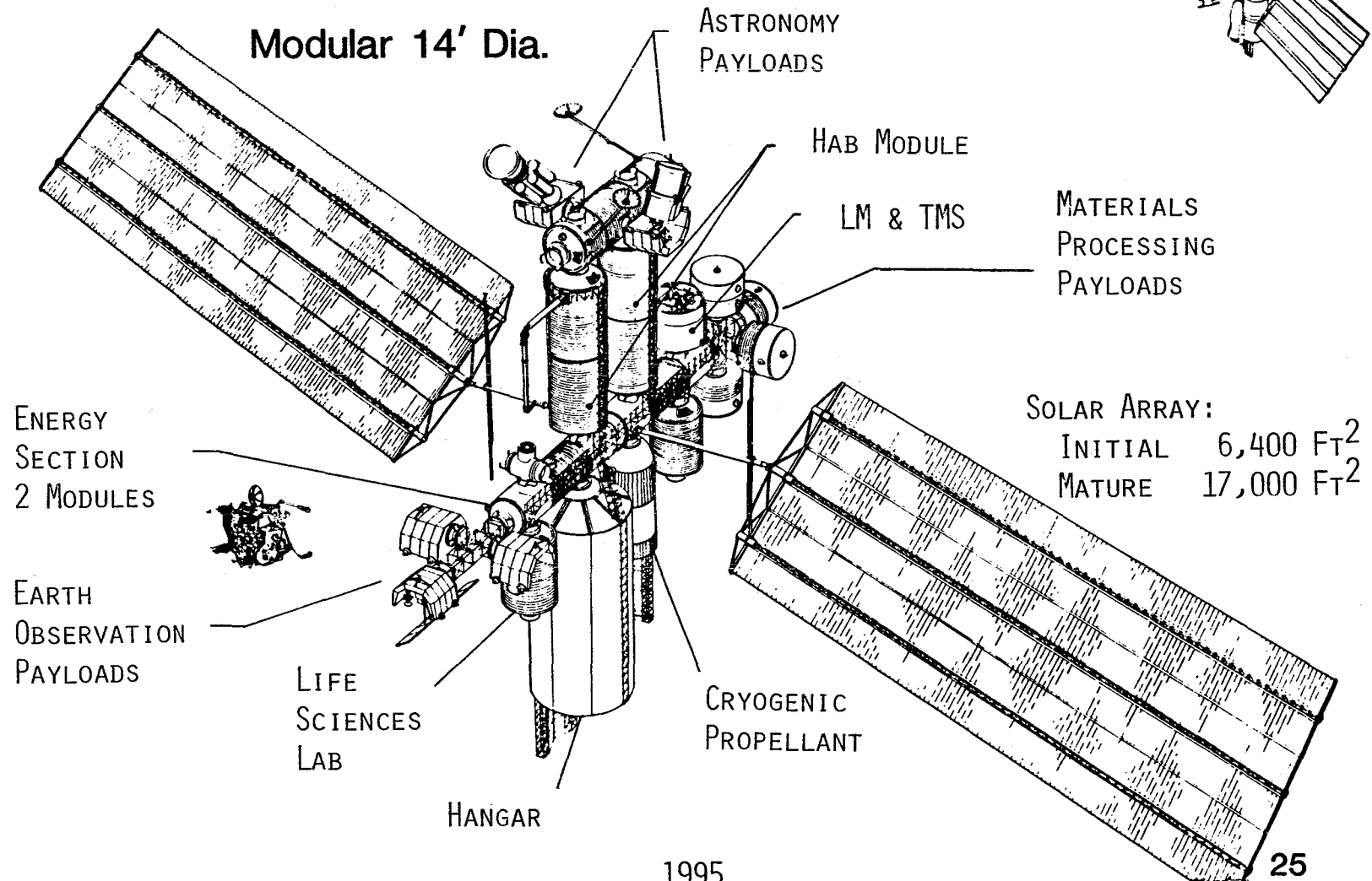
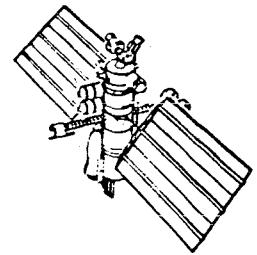
OVERALL LENGTH 162.0 FT
DIAMETER 27.6 FT
PAYLOAD BAY 25 FT DIA X 90 FT LONG
INERT WEIGHT 47,650 LBS



USEABLE VOLUME - 48,000 FT

- HABITABLE AREAS
- ENERGY SECTION
- HANGAR (PARTIAL)
- OTHER SPECIAL COMPARTMENTS

Mature Configuration (STS)



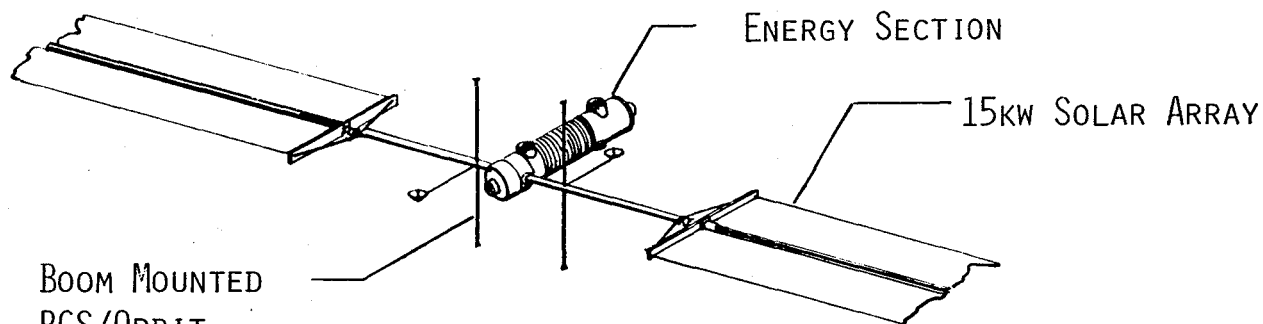
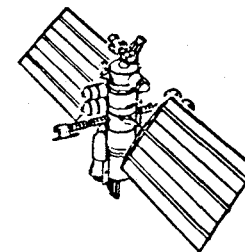
1995

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25

Early Configuration

Modular 14' Dia.

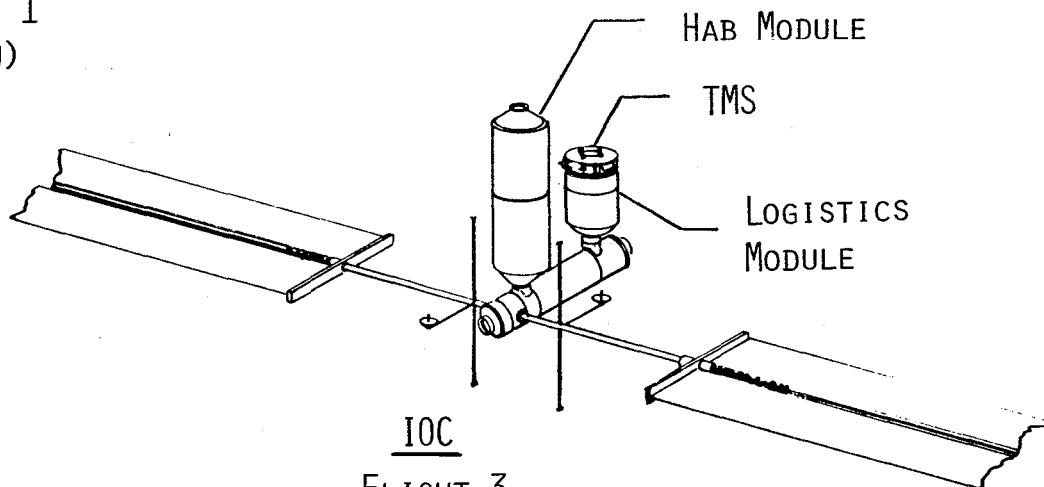


BOOM MOUNTED
RCS/ORBIT
MAINTENANCE
THRUSTERS

ENERGY SECTION

15kw SOLAR ARRAY

FLIGHT 1
(1990)



HAB MODULE

TMS

LOGISTICS
MODULE

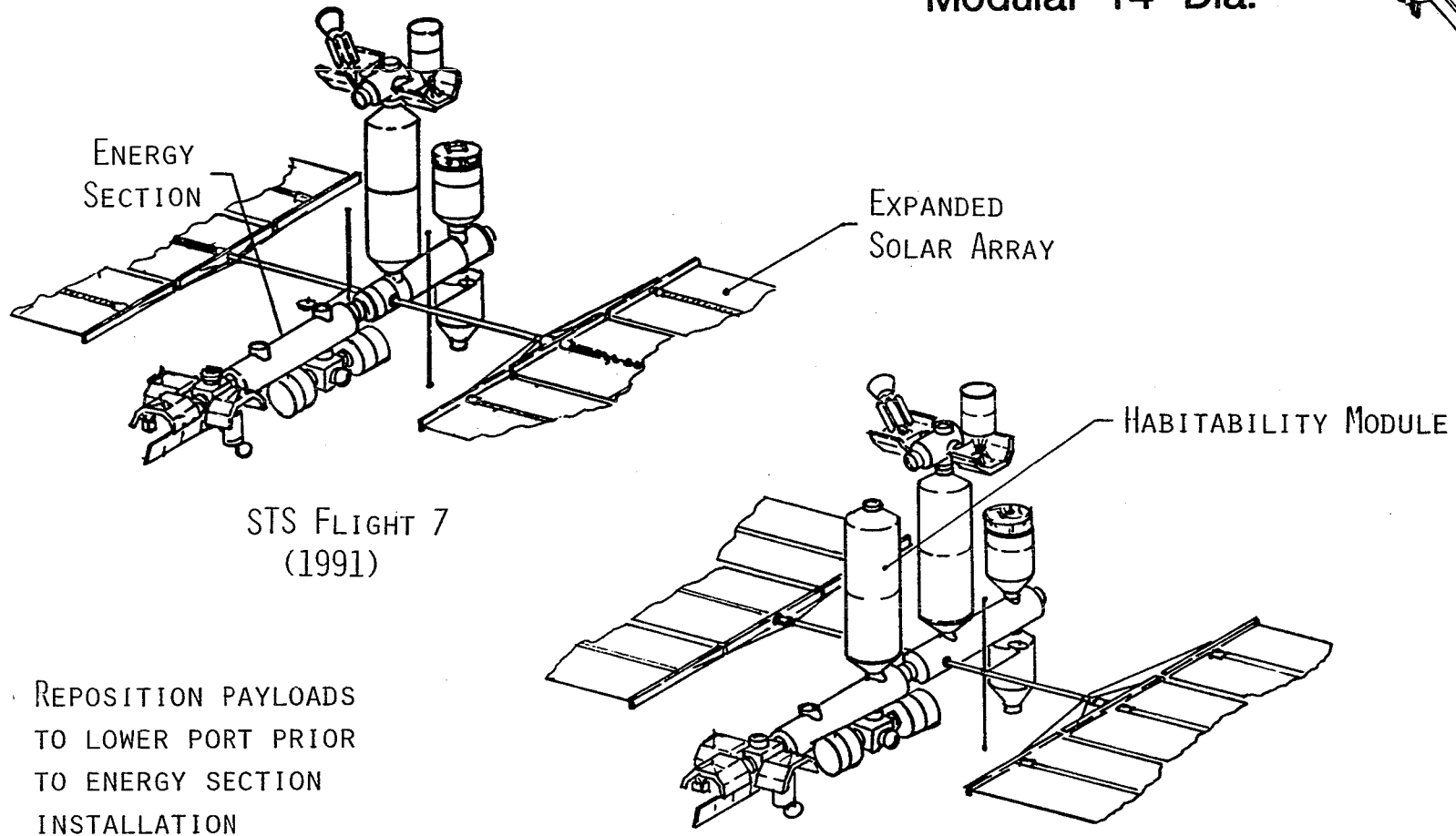
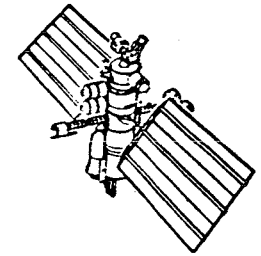
IOC
FLIGHT 3
(1991)

26

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Intermediate Configuration

Modular 14' Dia.



STS FLIGHT 7
(1991)

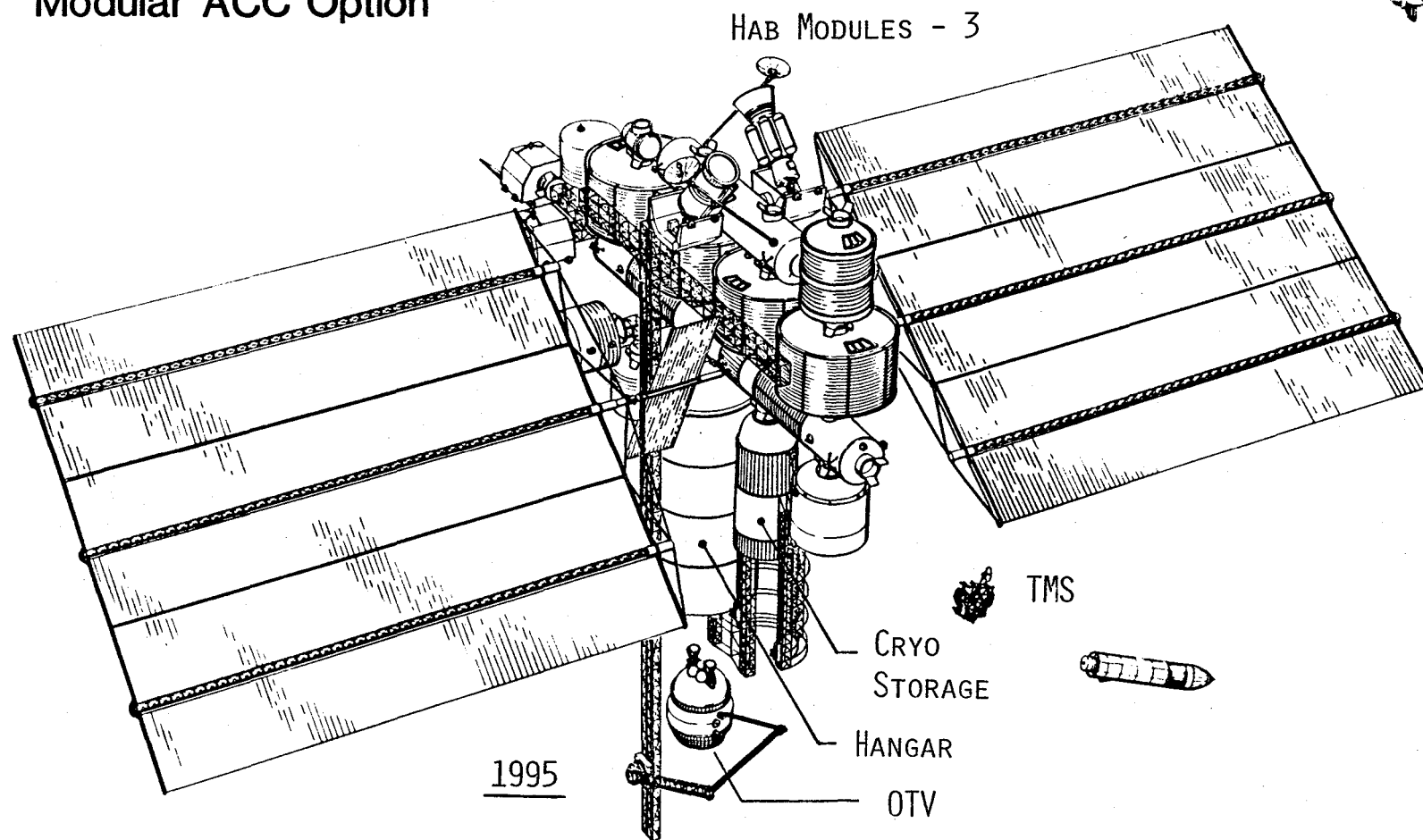
REPOSITION PAYLOADS
TO LOWER PORT PRIOR
TO ENERGY SECTION
INSTALLATION

STS FLIGHT 8
(1992)

MARTIN MARIETTA

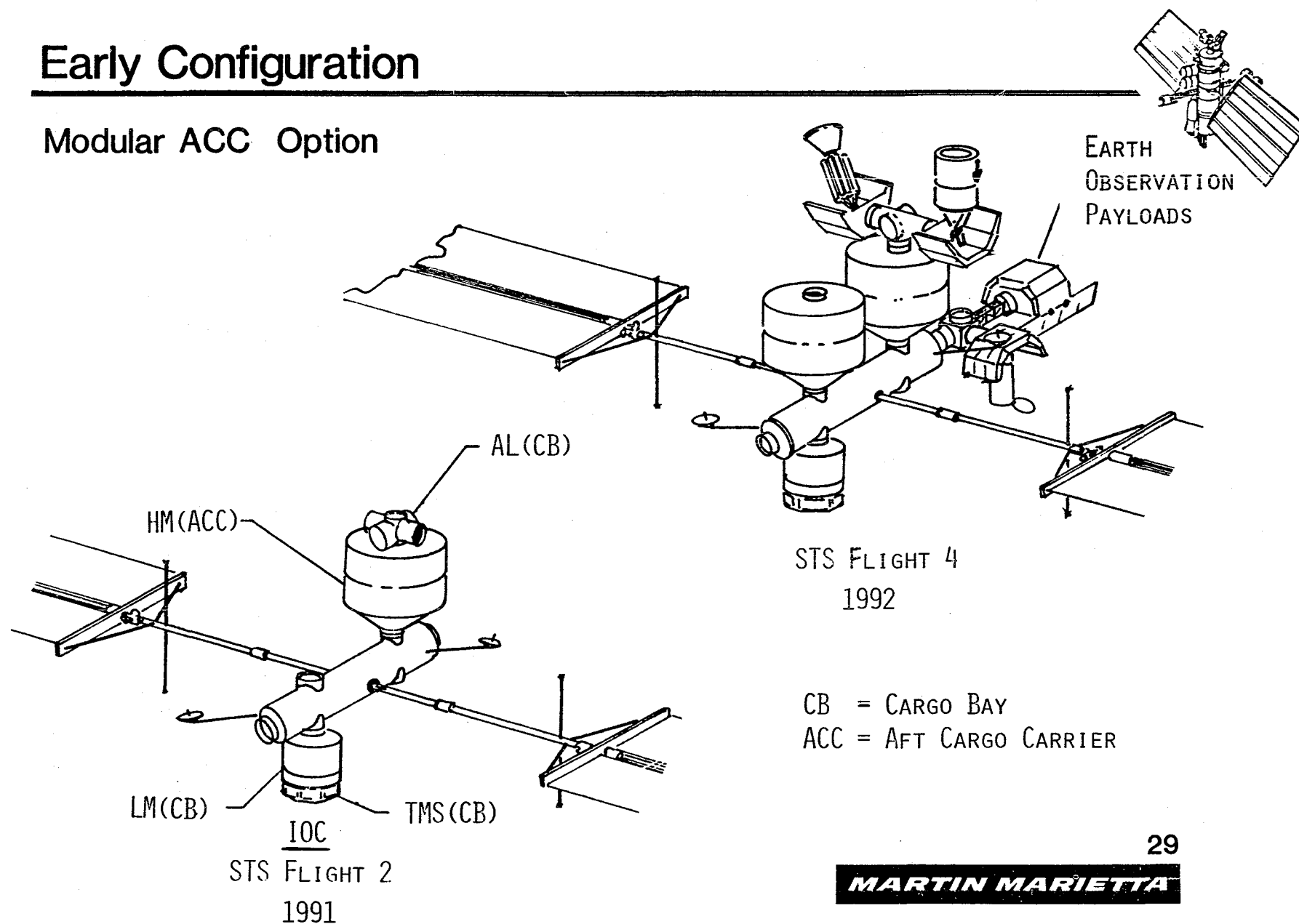
Mature Configuration (ACC)

Modular ACC Option



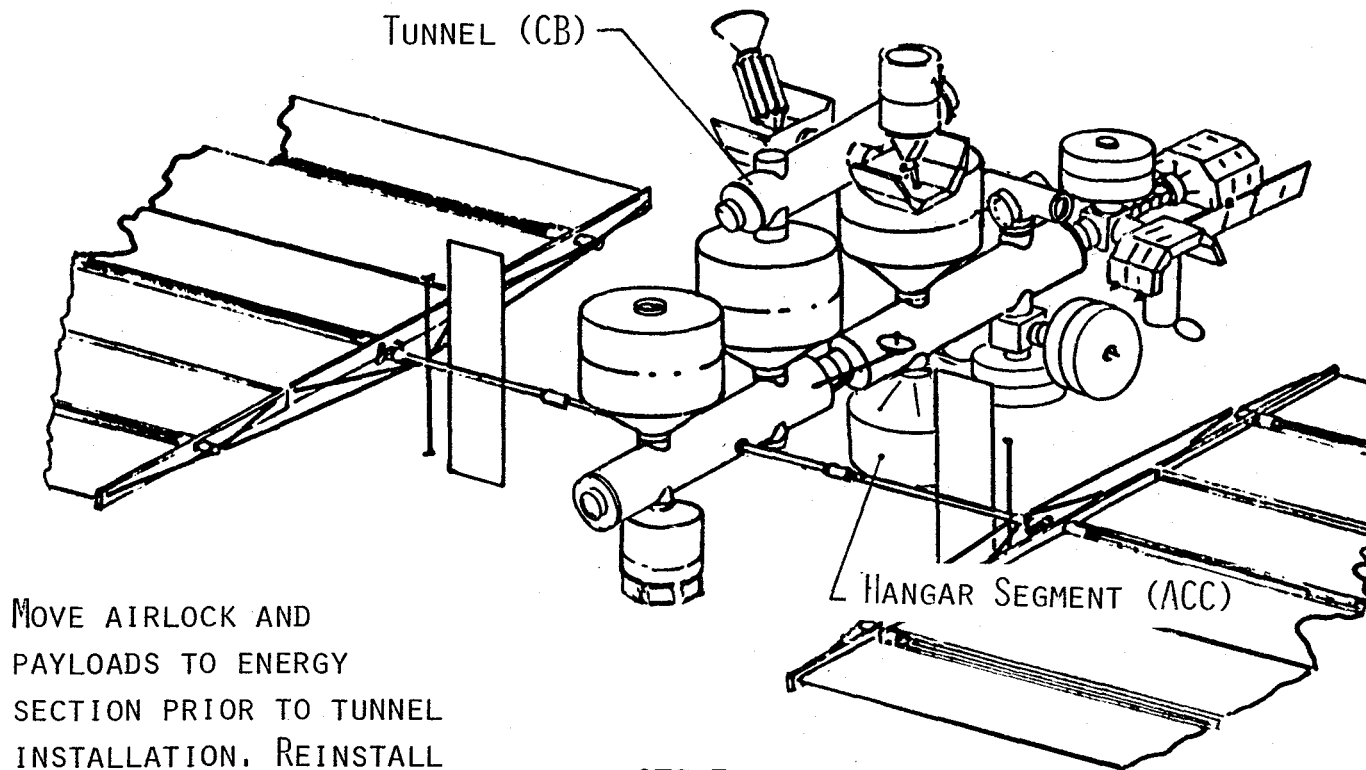
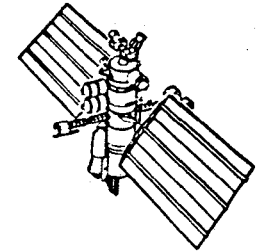
Early Configuration

Modular ACC Option



Intermediate Configuration

Modular ACC Option



MOVE AIRLOCK AND
PAYLOADS TO ENERGY
SECTION PRIOR TO TUNNEL
INSTALLATION. REINSTALL
PAYLOADS ON TUNNEL MODULE

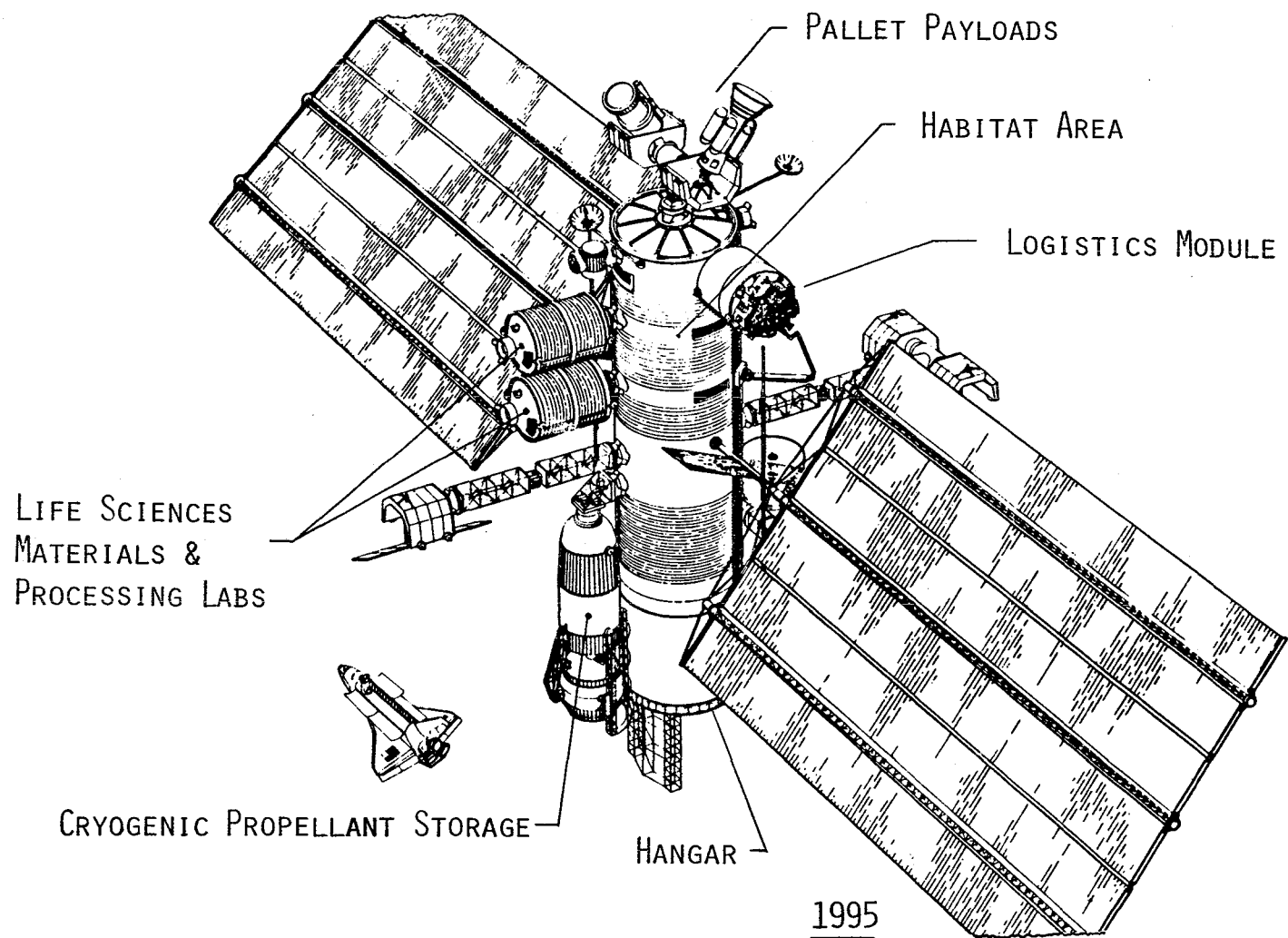
STS FLIGHT 7

1993

30

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Mature SDV Configuration

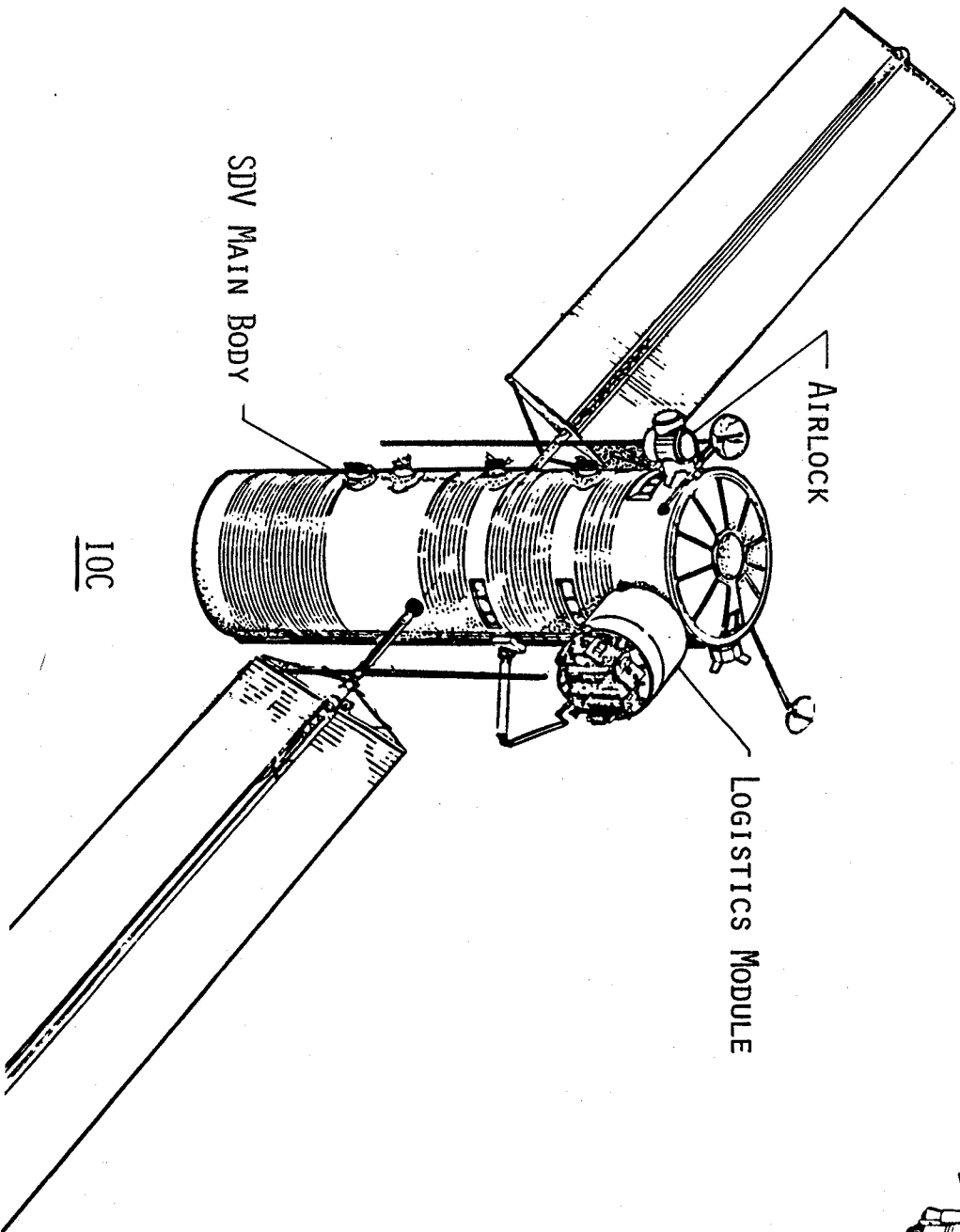


1995

31

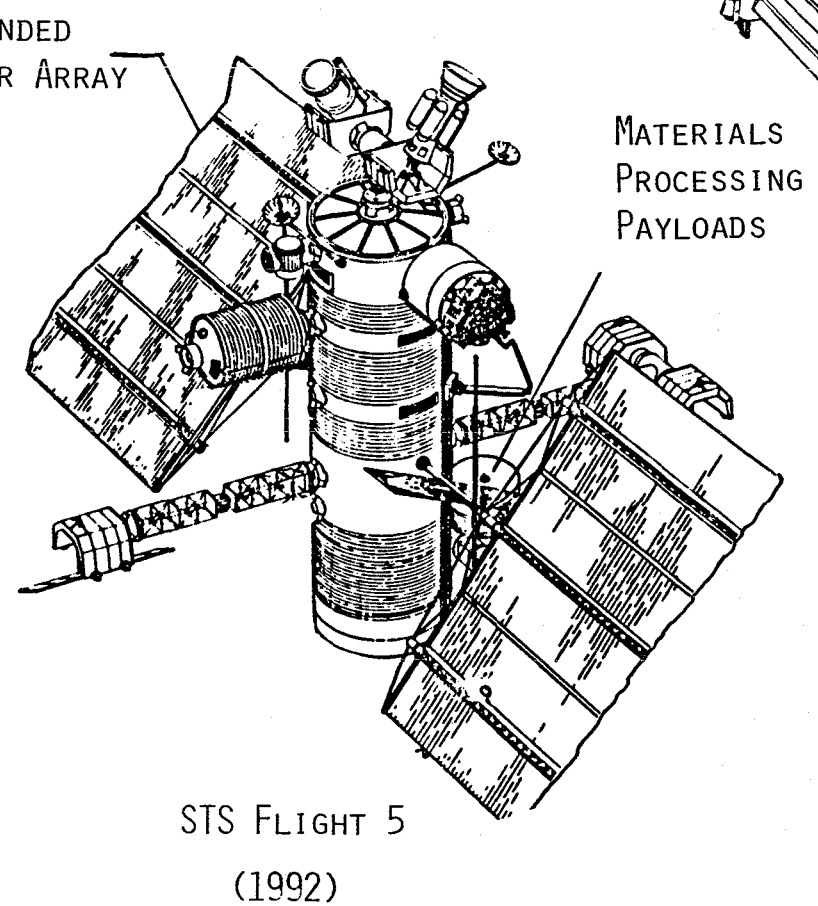
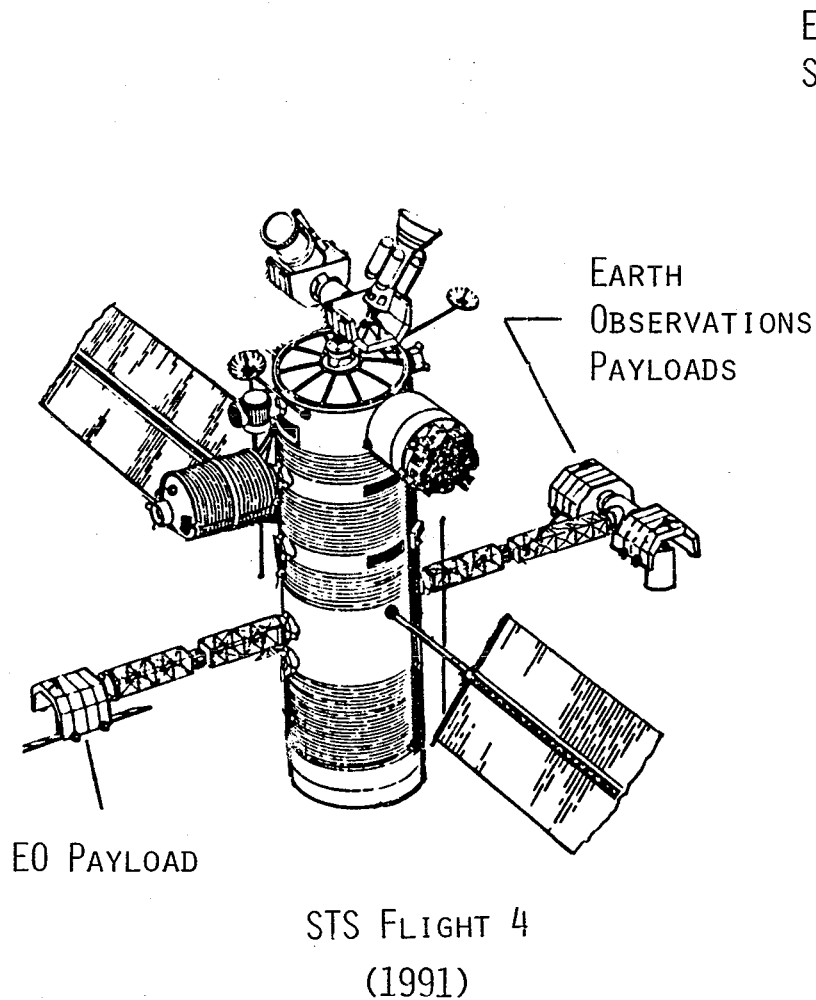
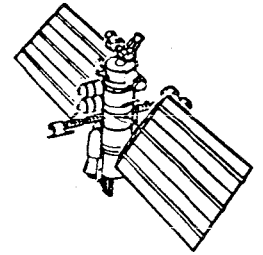
MARTIN MARIETTA

Early SDV Configuration

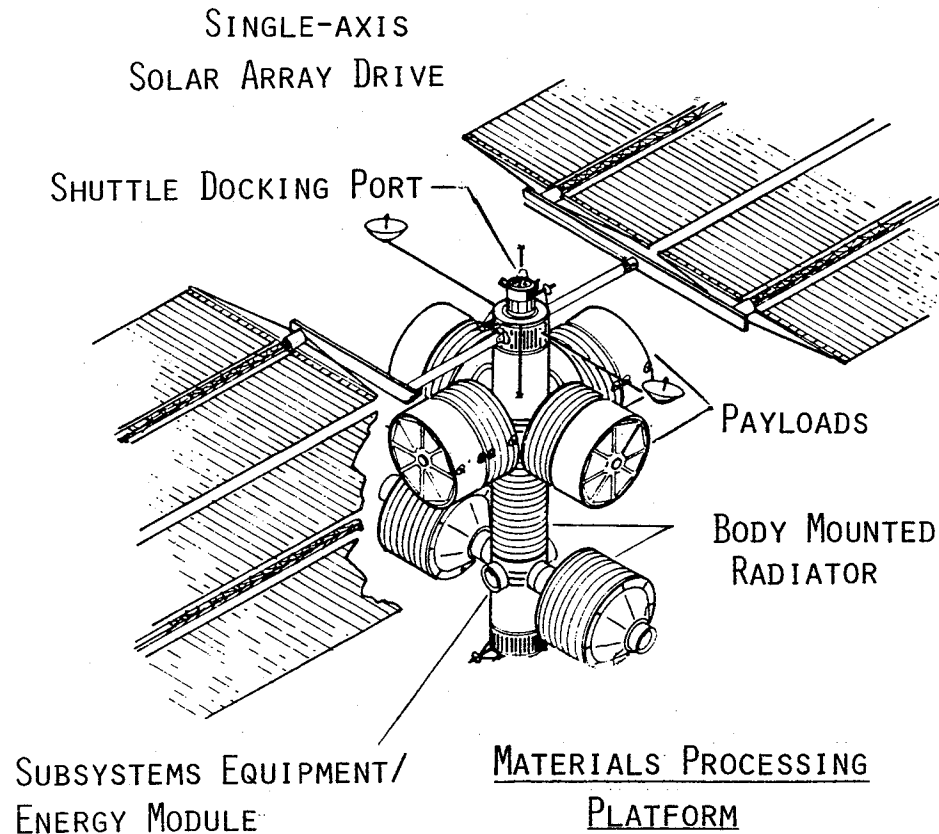
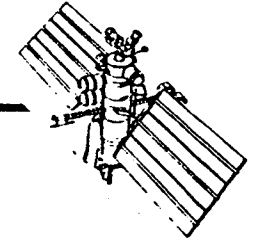


10C

Intermediate SDV Configuration

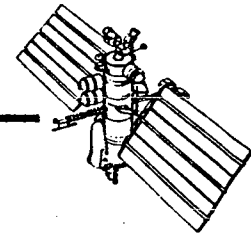


Platform Approach



- PLATFORM DESIGN EMPHASIZES COMMONALITY WITH SPACE STATION
 - ENERGY SECTION
 - SOLAR ARRAY
 - SUBSYSTEMS
- REDUCES ACQUISITION COSTS
- COMPONENT INTERCHANGEABILITY SIMPLIFIES SPARE PARTS LOGISTICS
- APPLICABLE TO ASTRONOMY PLATFORM

ETCLS Evolution



IOC

91 92 93 94 95 96 97 98 99 2000

Early ETCLS System

- RESUPPLY DRINKING WATER
- USE CONDENSATE FOR HYGIENE WATER
- REGENERABLE CO₂ REMOVAL

ETCLS —

Environmental Thermal Control
& Life Support

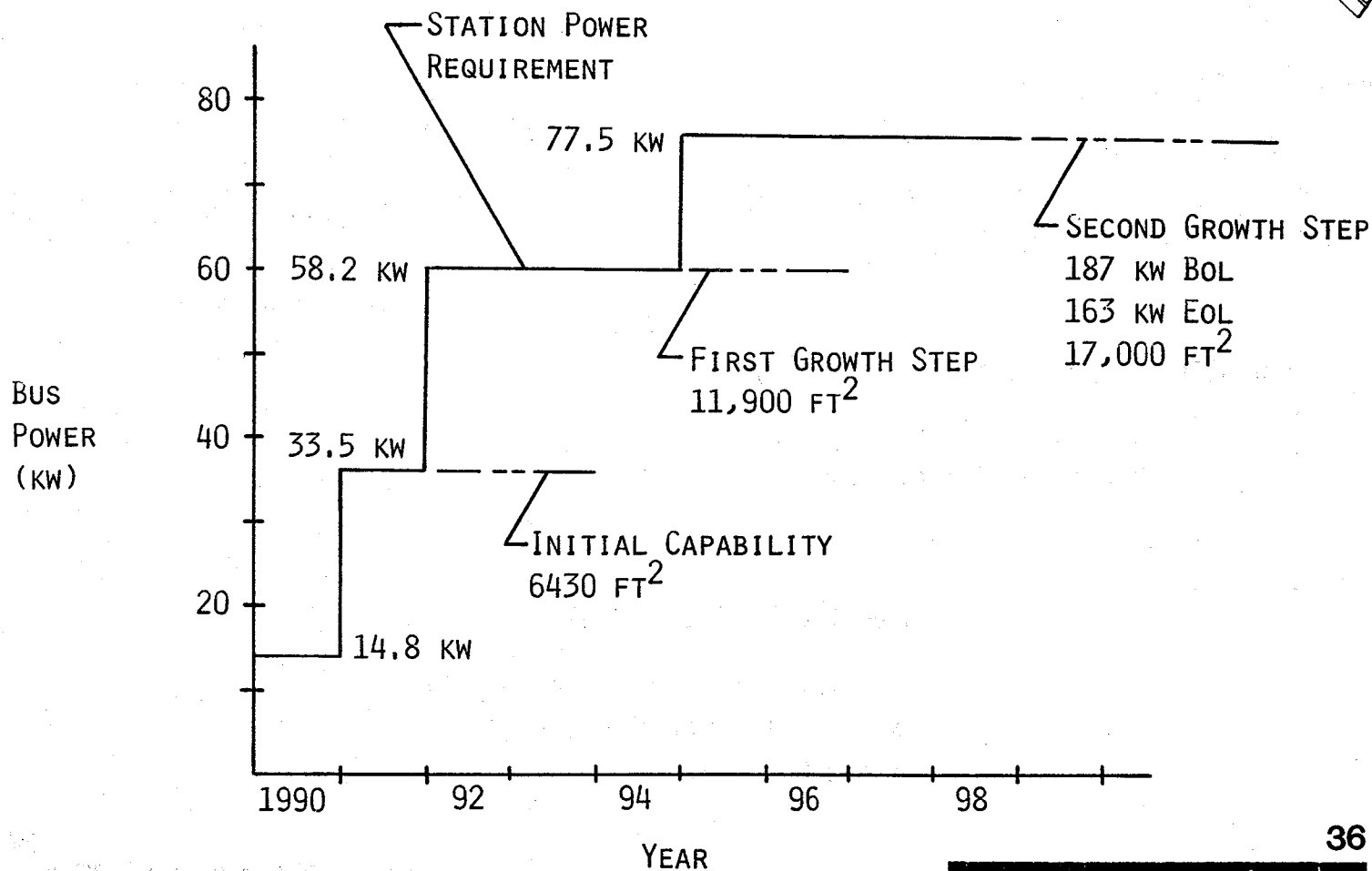
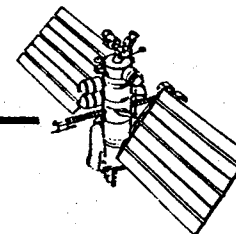
Intermediate ETCLS System

- LIMITED CLOTHES WASHING
- EVALUATE WASTEWATER PROCESSING

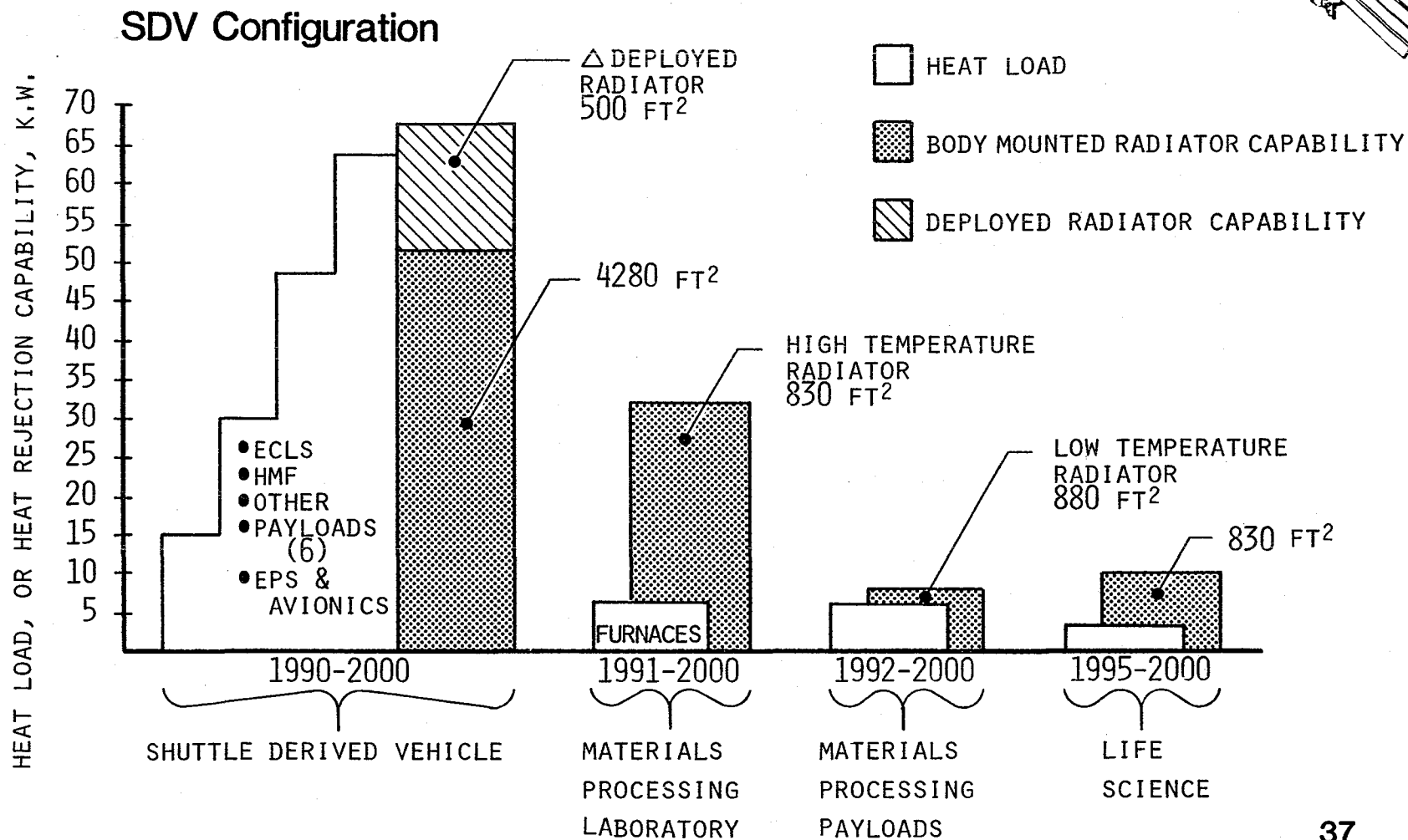
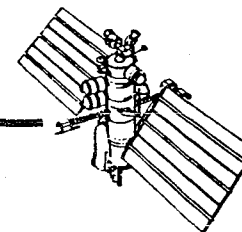
Mature ETCLS System

- CLOSED LOOP WATER & OXYGEN
- FULL HYGIENE CAPABILITY
- MINIMAL RESUPPLY

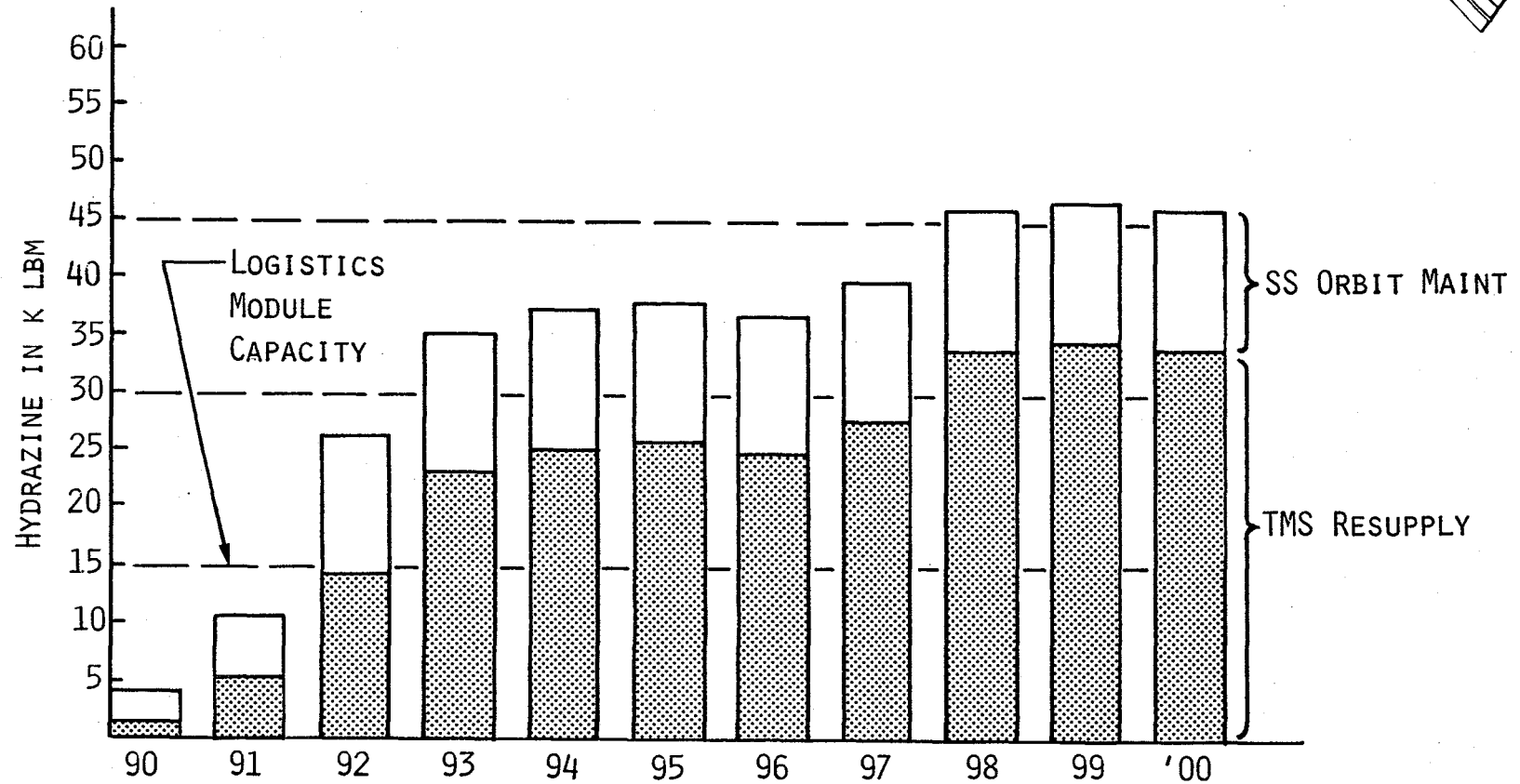
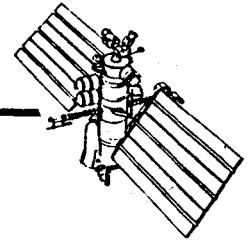
Power Requirements Growth



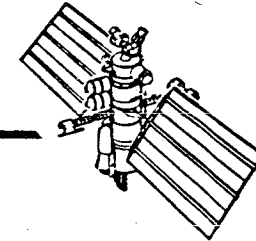
Heat Rejection Capability



Hydrazine Usage



ET Scavenging Concept Feasibility



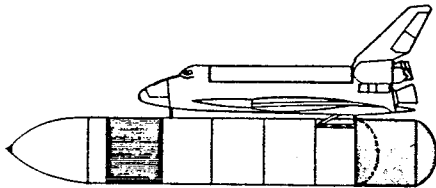
SUMMARY

- SIGNIFICANT BENEFITS
- TECHNICALLY FEASIBLE
- NASA/MMC STUDIES

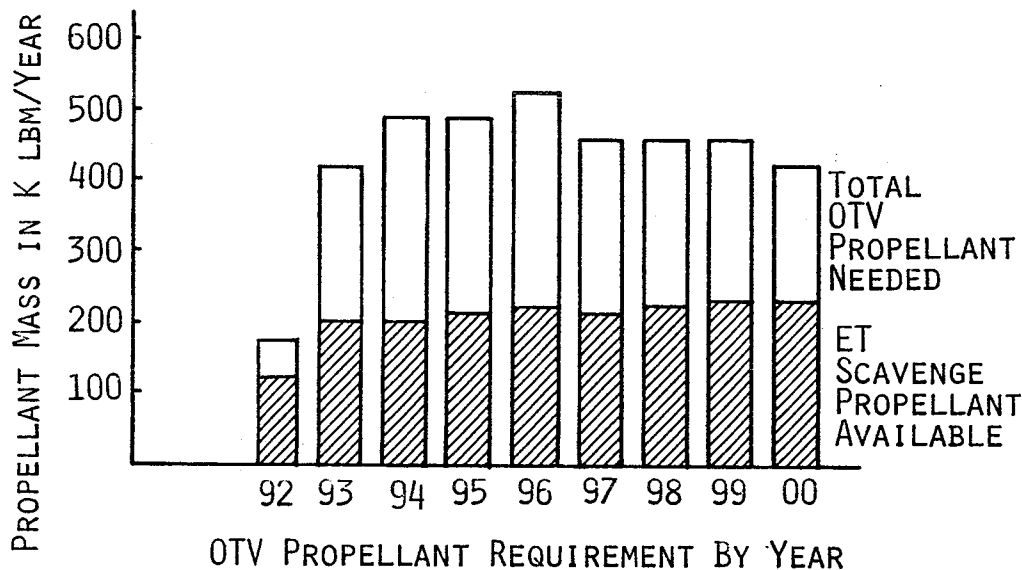
BENEFITS

- 9000 LBS PROPELLANT AVAILABLE FOR SCAVENGING
- ESTIMATED SAVINGS 2-4 STS FLIGHTS PER YEAR (6-9%) 1994-2000

- MANIFESTING ET PROPELLANT PAYLOAD WITH VOLUME LIMITED STS PAYLOADS INCREASES PROPELLANTS AVAILABLE AT SPACE STATION



REQUIREMENTS



RELATED ACTIVITIES

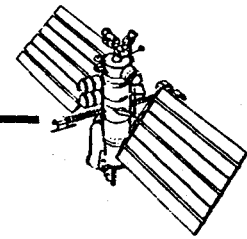
IR&D

- MMC/MICHOUD-ET PROPELLANT UTILIZATION
- MMC/DENVER AEROSPACE-CRYOGENIC FLUID TECHNOLOGY

CONTRACTS

- MSFC/JSC-PROPELLANT SCAVENGING (NEAR-TERM RFP)
 - JOINTLY COORDINATED AND FUNDED ET SCAVENGING-CARGO BAY AND ACC
- LERC-CRYOGEN FLUID MANAGEMENT FACILITY (CFMF)
 - DETAILED DESIGN OF FLIGHT READY CFMF
 - THERMAL/FLUID DYNAMICS-CRYOGENICS IN SPACE

Subsystem Concepts



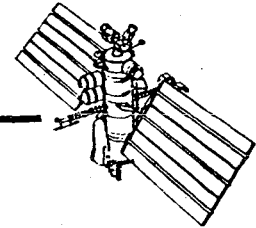
Propulsion

- HYDRAZINE USED FOR SS ORBIT MAINTENANCE AND ATTITUDE CONTROL
 - USES 8 BOOM-MOUNTED 30 LB THRUSTERS
- HYDRAZINE STORAGE (15000 LBS) IN LOGISTICS MODULE
- INTER-MODULE HYDRAZINE TRANSFER CAPABILITY
- CRYOGEN STORAGE OF 70000 LBS PROVIDED TO RESUPPLY OTV

Attitude Control

- GRAVITY GRADIENT ATTITUDE CONTROL OF PITCH AND ROLL AXES
 - PROVIDES COARSE STABILIZATION
- FINE POINTING PROVIDED SEPARATELY FOR PAYLOADS
- EARLY CONFIGURATION MAY AUGMENT RCS WITH CMGs
- ORBITAL RATE (PITCH AXIS) PROVIDES GYROSCOPIC STABILIZATION IN YAW AND ROLL AXES

Subsystem Concepts (Cont.)

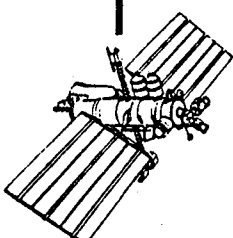


Data Processing

- DISTRIBUTED ARCHITECTURE
- END-TO-END SYSTEM INTERFACING SS DATA BUS WITH GROUND PROCESSORS
- ESTIMATE DATA STORAGE IN THE RANGE OF
 1.2×10^{10} TO 1.2×10^{11} IS REQUIRED
- NEED EXISTS FOR SIGNIFICANT DATA REDUCTION OF USER DATA

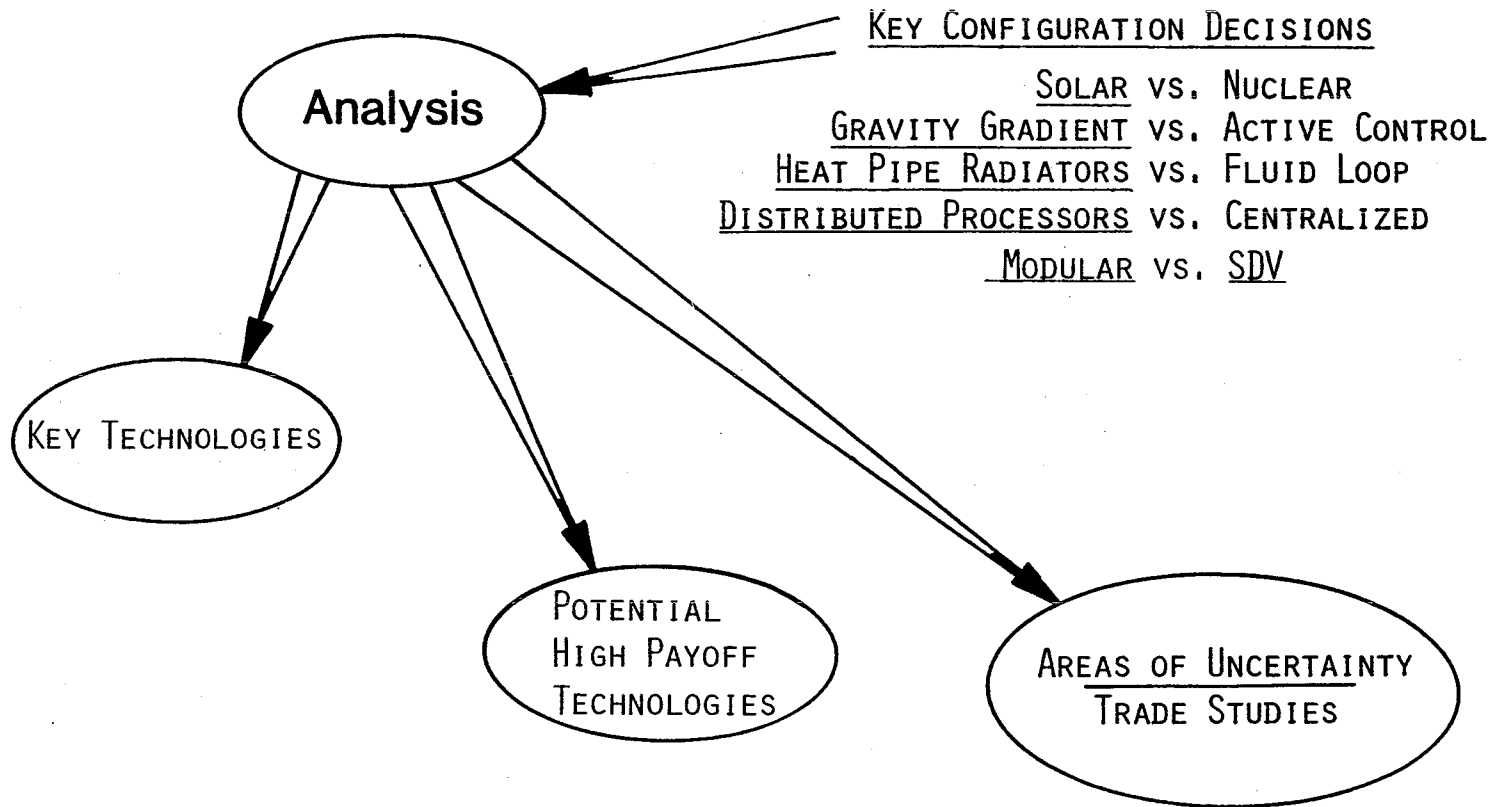
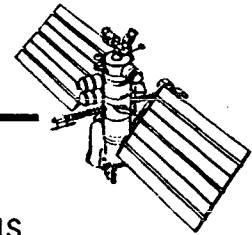
Communications

- NUMEROUS RF INTERFACES MAY REQUIRE OPERATIONS AT UHF, L, S & KU BANDS, AT 40-60 GHZ, AND AT LASER WAVELENGTH
- HIGH USER DATA RATES AND VOLUME DRIVES NEED FOR STORE & DUMP APPROACH
- DATA DUMPS AS FREQUENT AS EVERY ORBIT MAY BE NECESSARY
- RF LINKS MAINTAINED WITH CO-ORBITING PLATFORMS

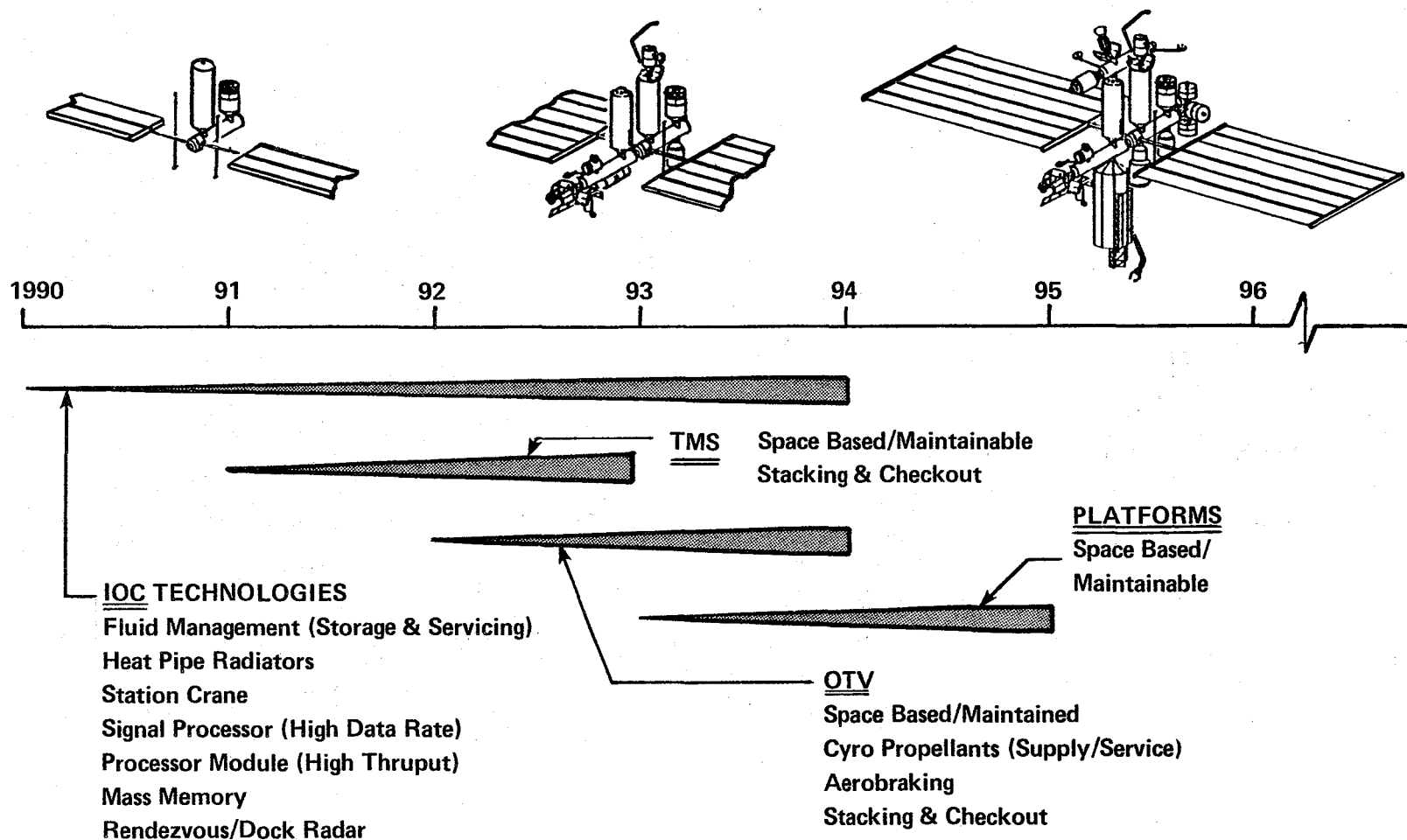


Key Technologies

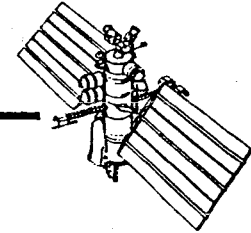
Technology Assessment



Key Technologies



Potential High Payoff Technologies



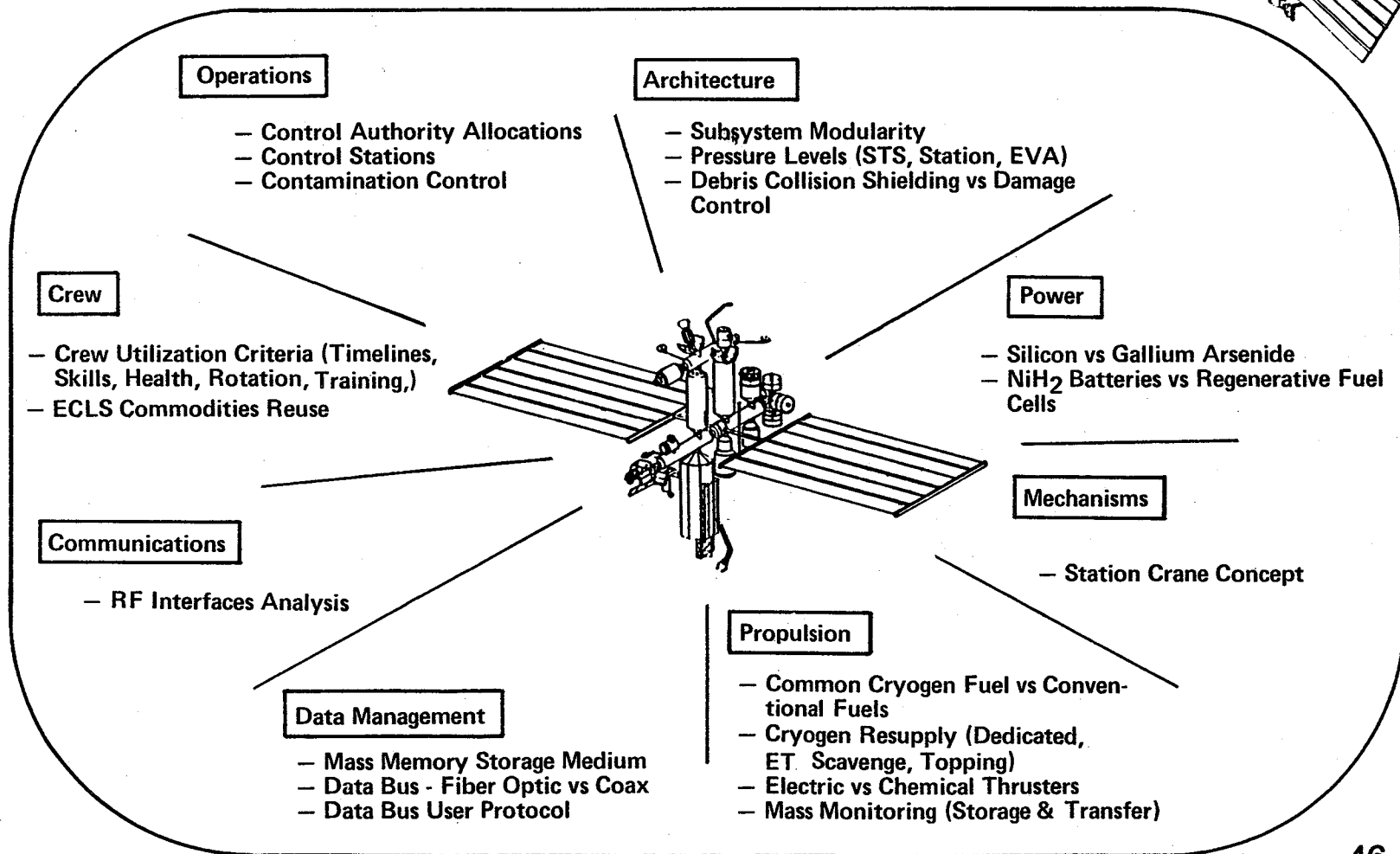
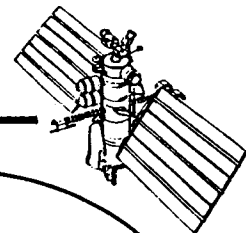
INCREASED EFFICIENCY SOLAR CELLS
(GAAs, THIN CELLS, MULTIBAND, CONCENTRATORS)
FUEL CELL/ELECTROLYSIS UNITS

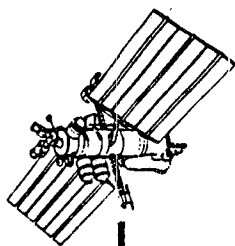
CRYOGEN FUELED TMS
ET PROPELLANT SCAVENGING
ELECTRIC THRUSTERS

TWO PHASE ISOTHERMAL HEAT TRANSFER SYSTEM
CONTACT HEAT EXCHANGERS

TETHER UTILIZATION

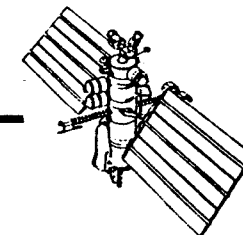
Areas Of Uncertainty – Analyses & Trades



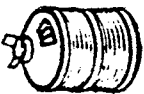




Associated Cost and Benefits

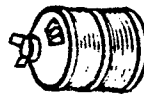
Programmatic Approach To Low Cost Space Station

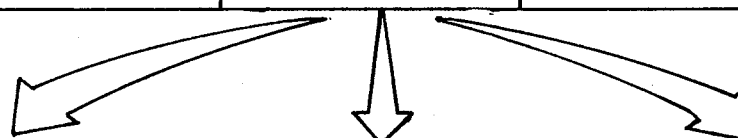


TRADITIONAL APPROACH

  	
QUAL. BACKUP FLIGHT	
SMALL MODULES RESULTING IN HIGH COST PER POUND	
INTENSIVE GROUND SUPPORT	

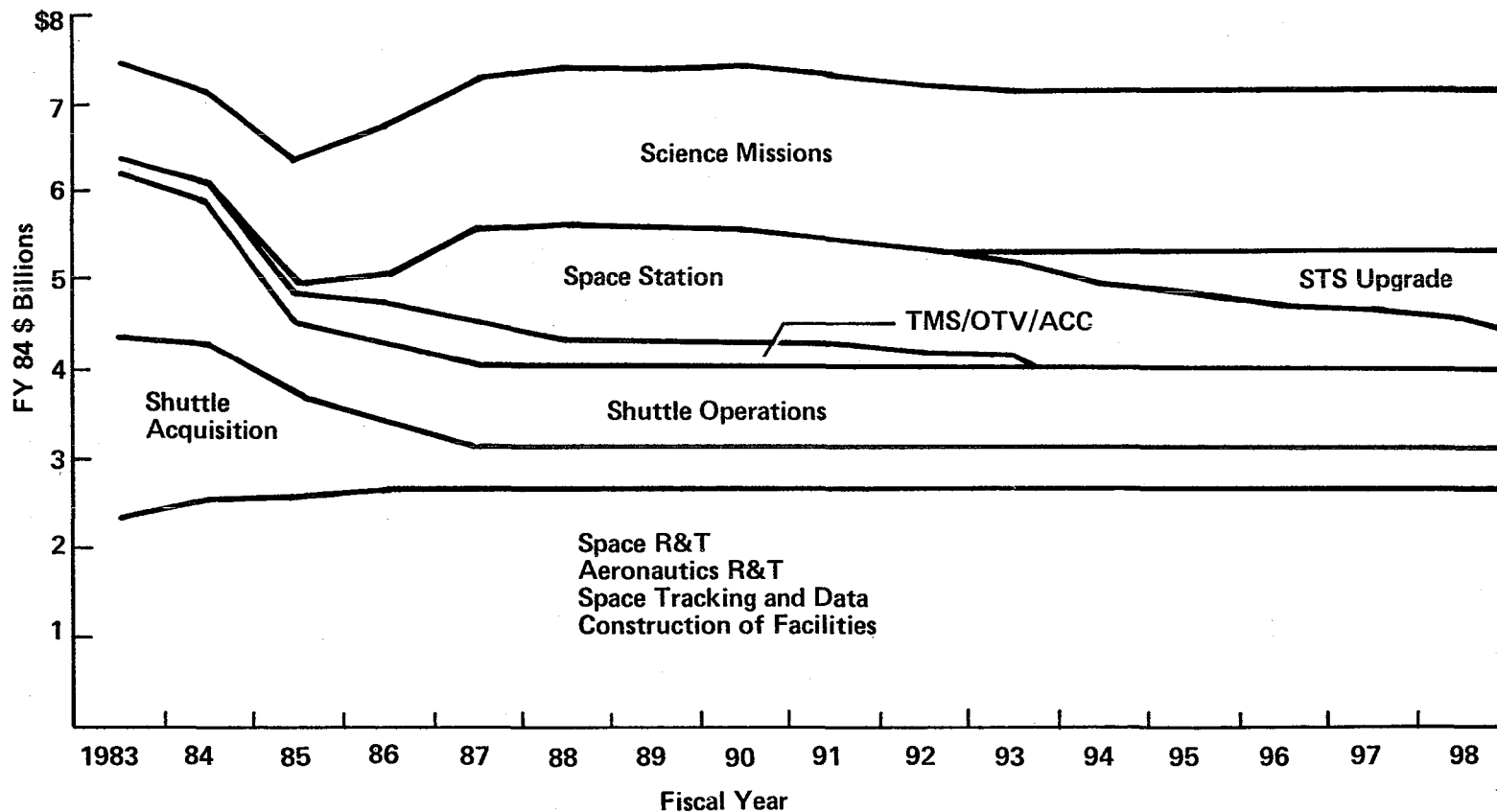
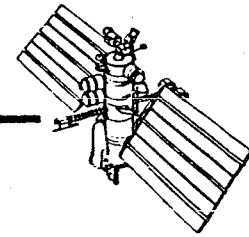
SPACE STATION APPROACH

	
PROTOFLIGHT	
STS CAPABILITY PERMITS LARGE MODULES WITH ECONOMY OF SCALE	
AUTONOMOUS OPERATION ALLOWS SIGNIFICANTLY REDUCED GND MISSION OPS	

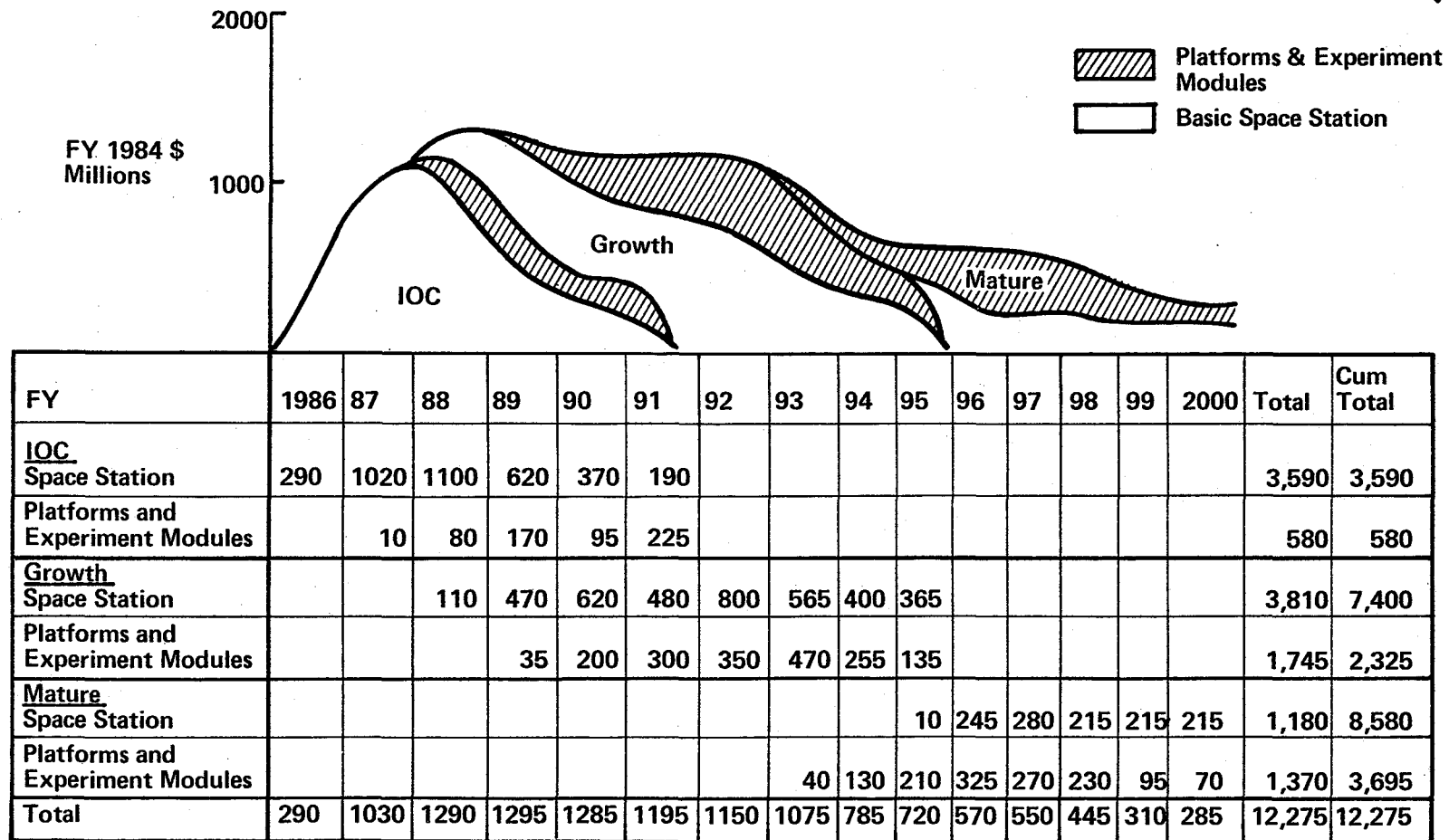
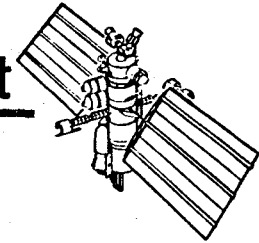


ACQUISITION = \$100,000/LB SPACELAB 35,000/LB SKYLAB OPERATION \approx 10% ACQ/YR	COST ESTIMATING RELATIONSHIPS	ACQUISITION = \$20,000/LB OPERATION \approx 3% ACQ/YR
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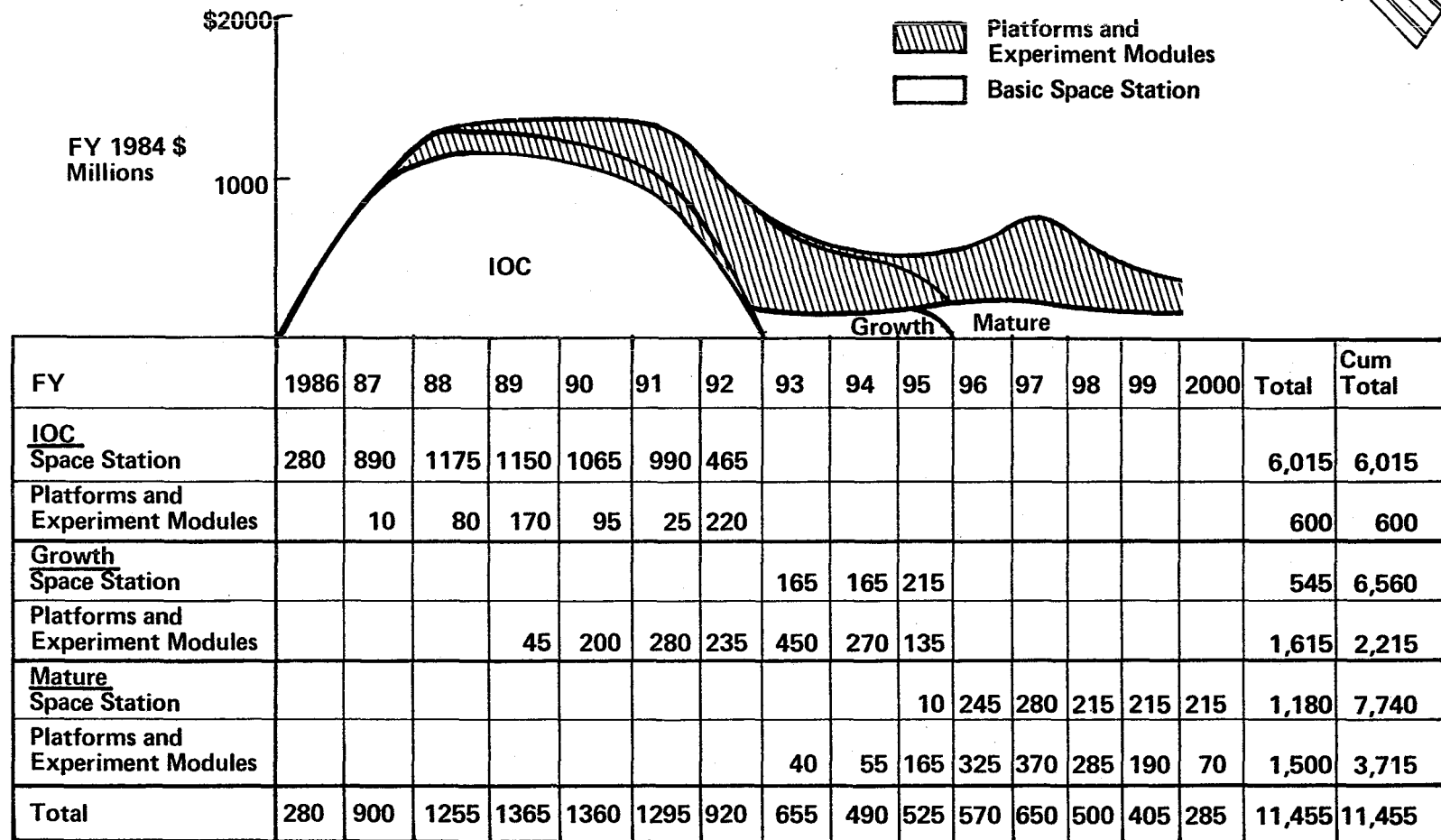
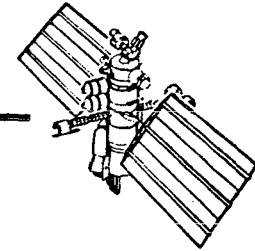
NASA Budget Projection – Affordability Analysis



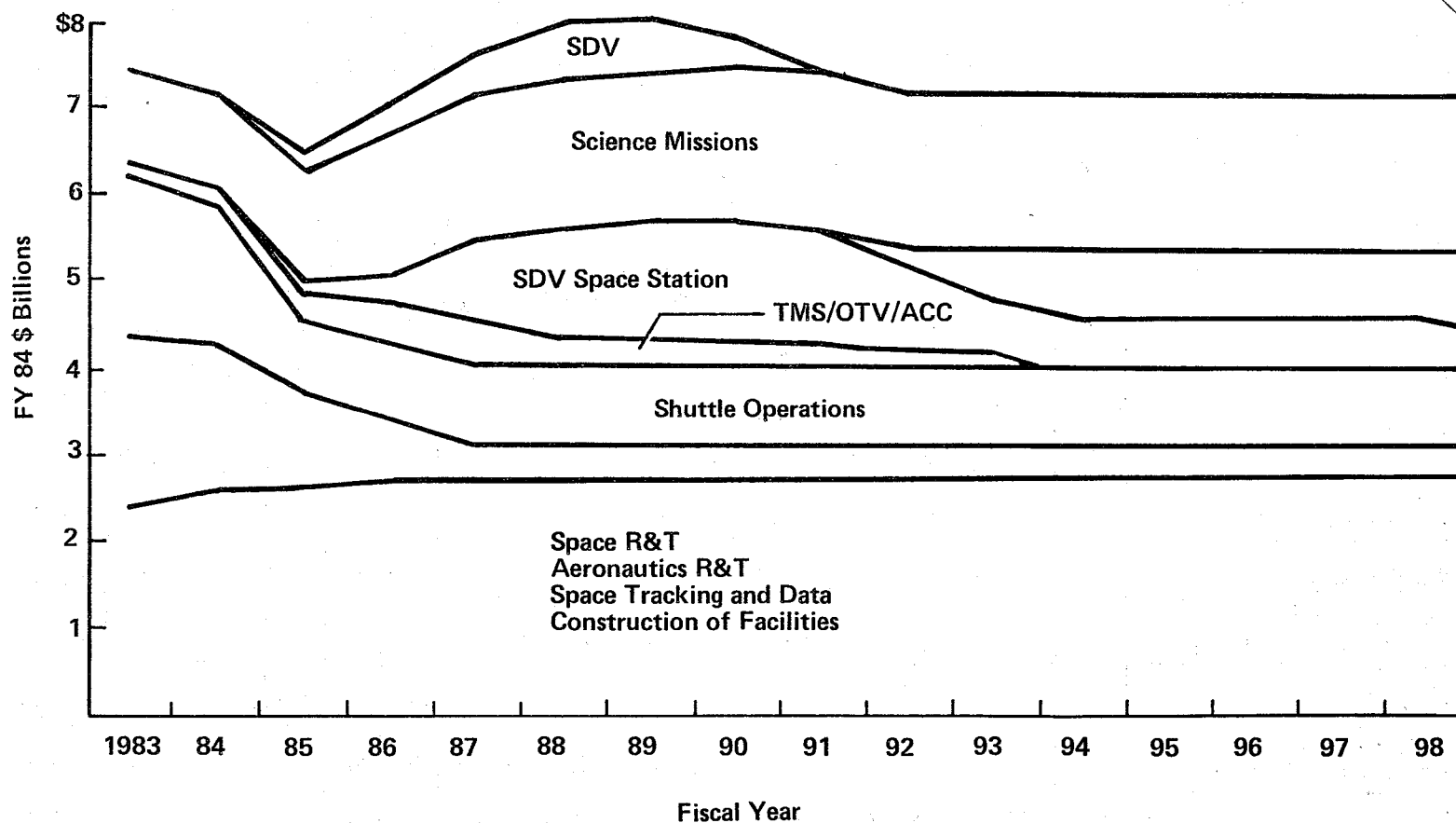
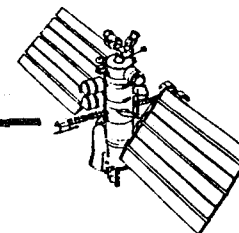
Space Station Costs By Phase – Modular Concept



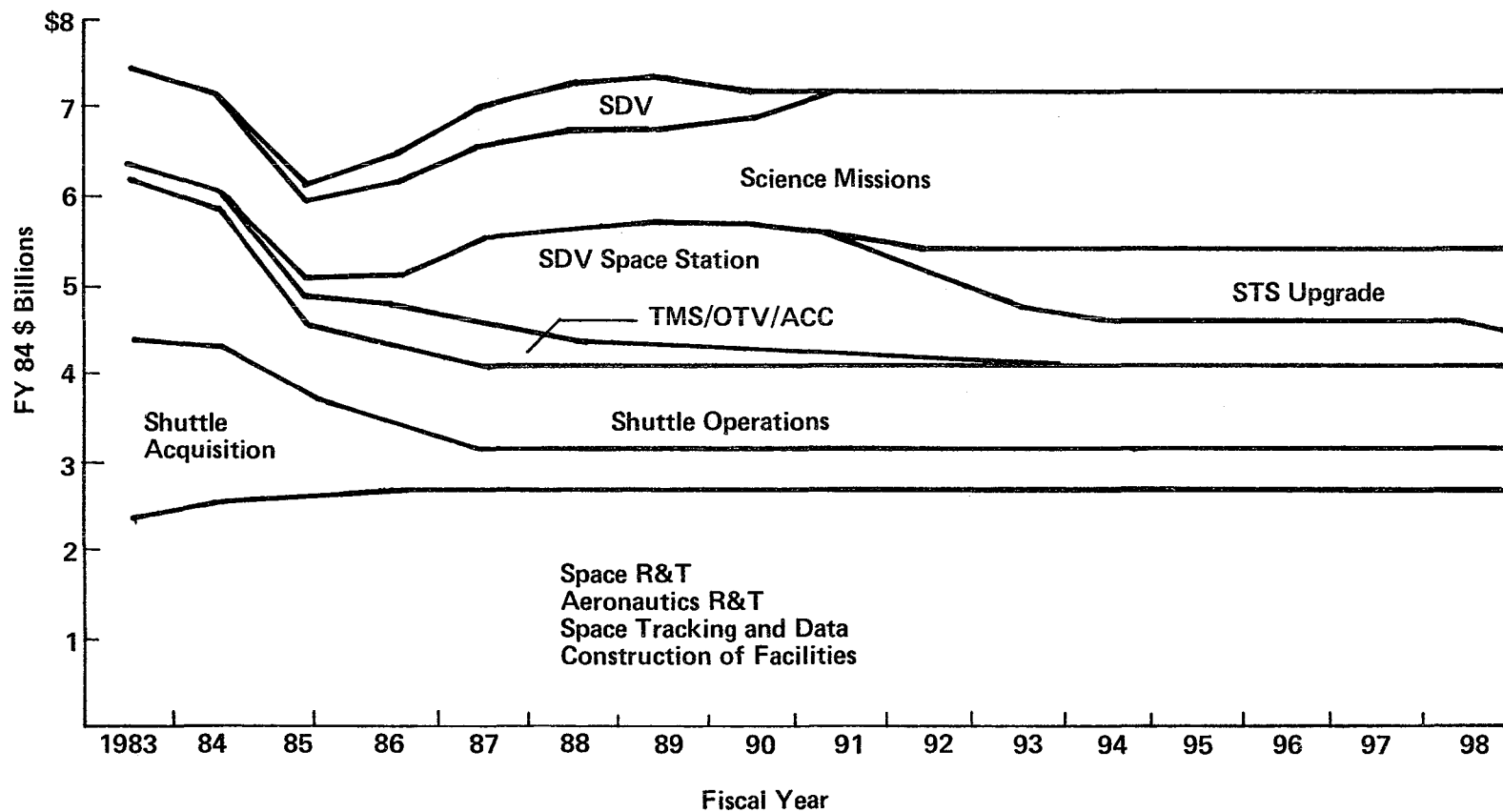
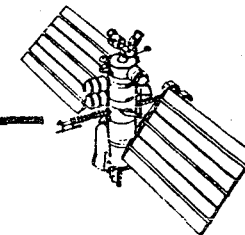
Space Station Costs By Phase – SDV Concept



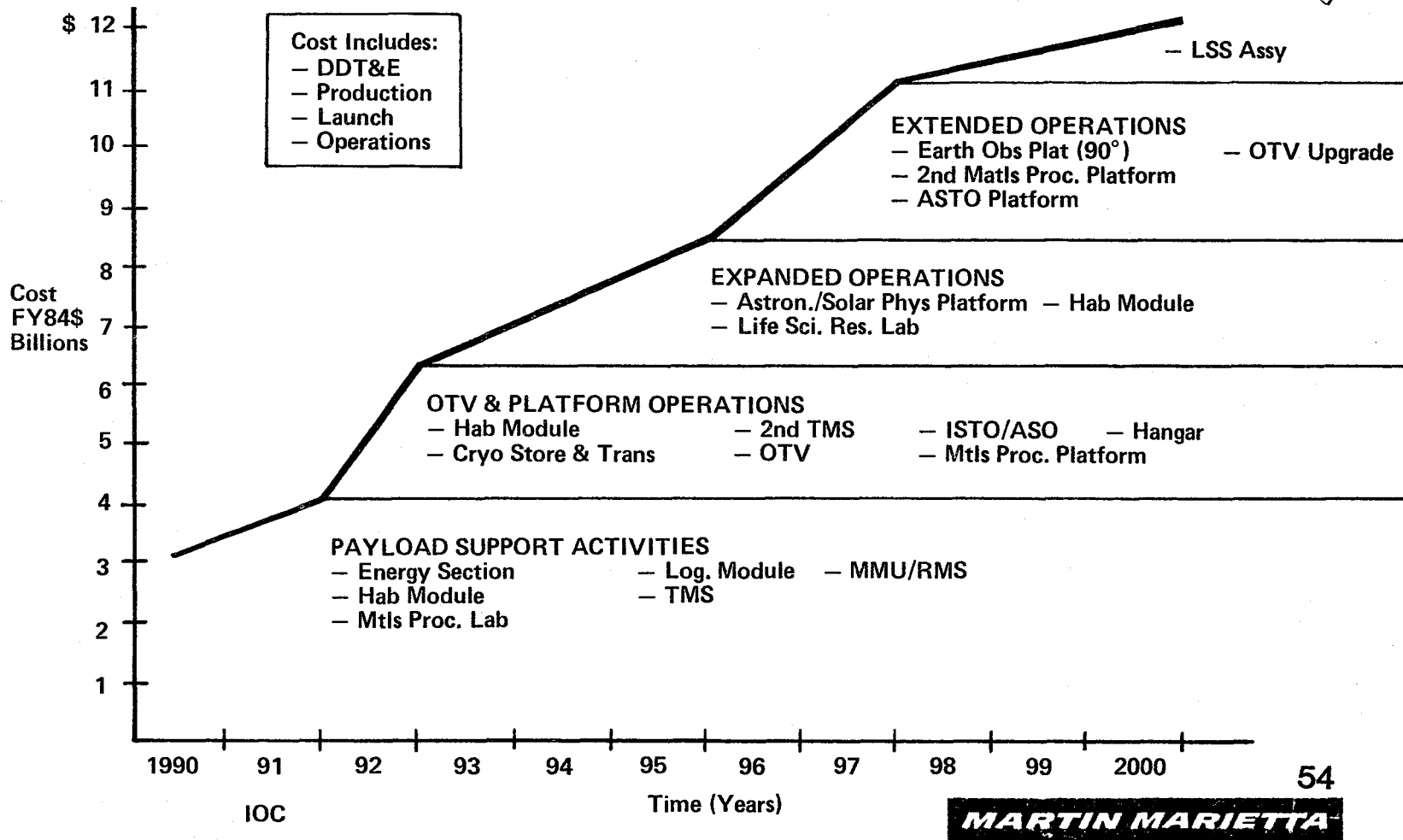
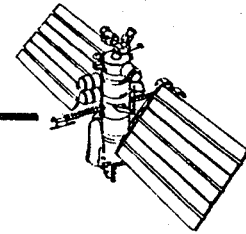
SDV Space Station Affordability Analysis – Baseline Science Budget



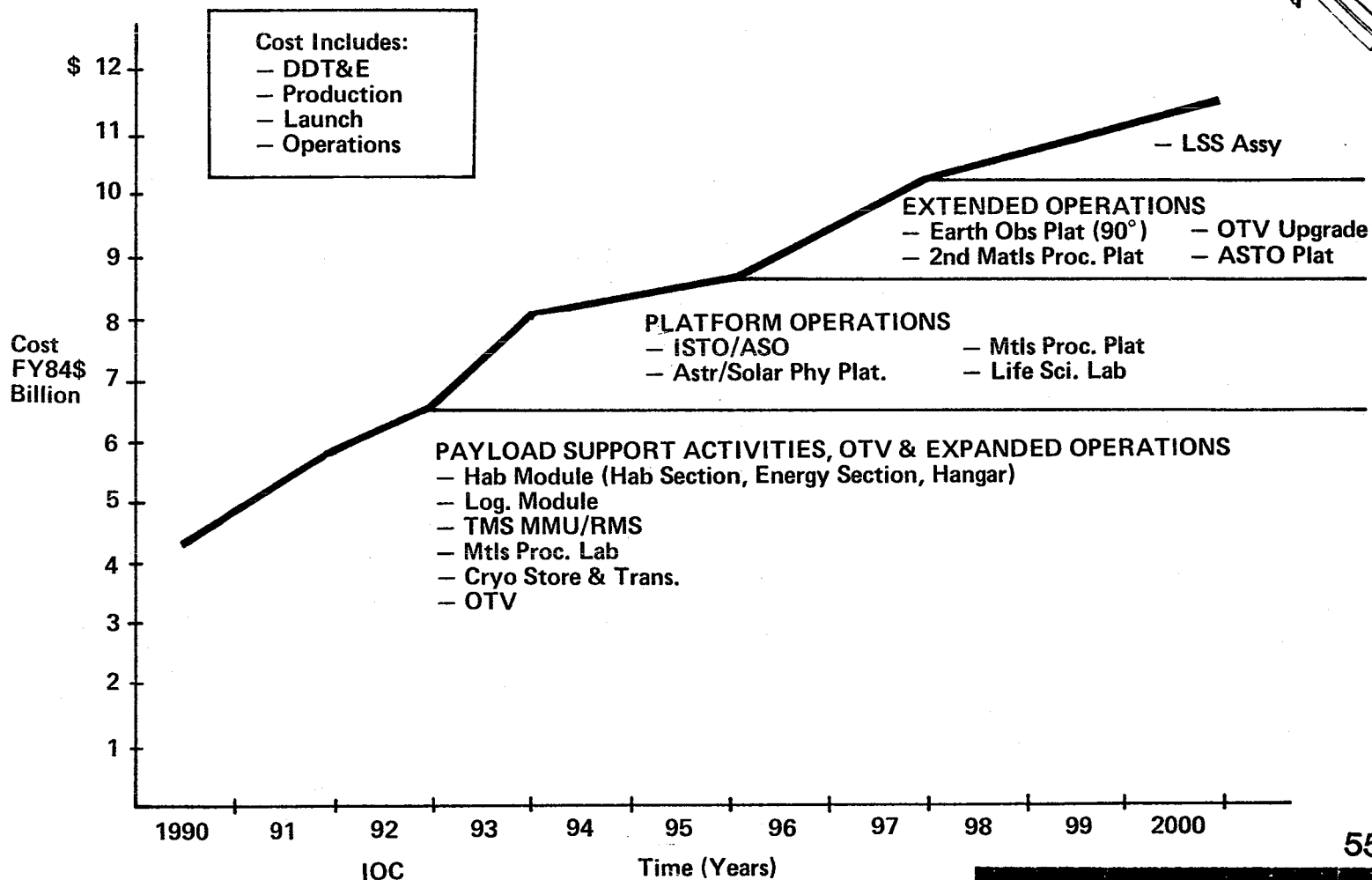
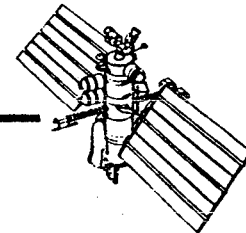
SDV Space Station Affordability Analysis – Constant Science Budget



Space Station Cost By Evolution Increment – Modular Concept

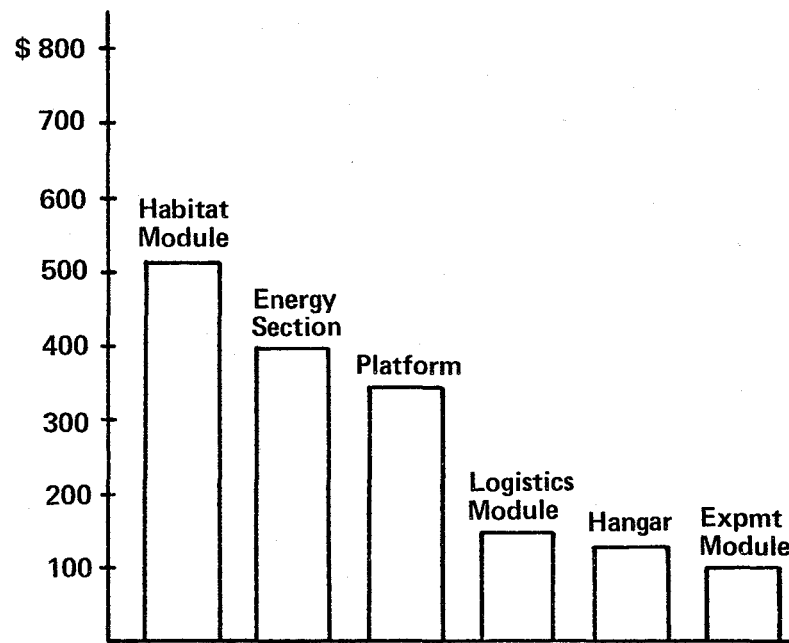
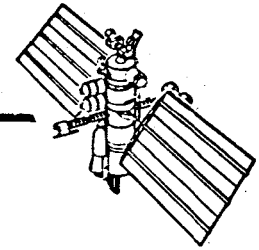


Space Station Cost By Evolution Increment – SDV Concept

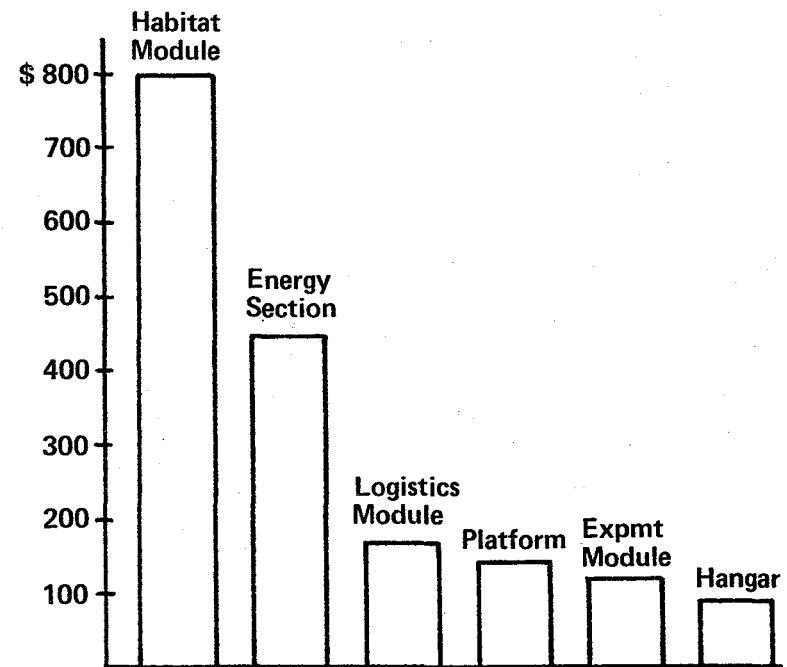


MARTIN MARIETTA

Space Station Cost Tall Poles

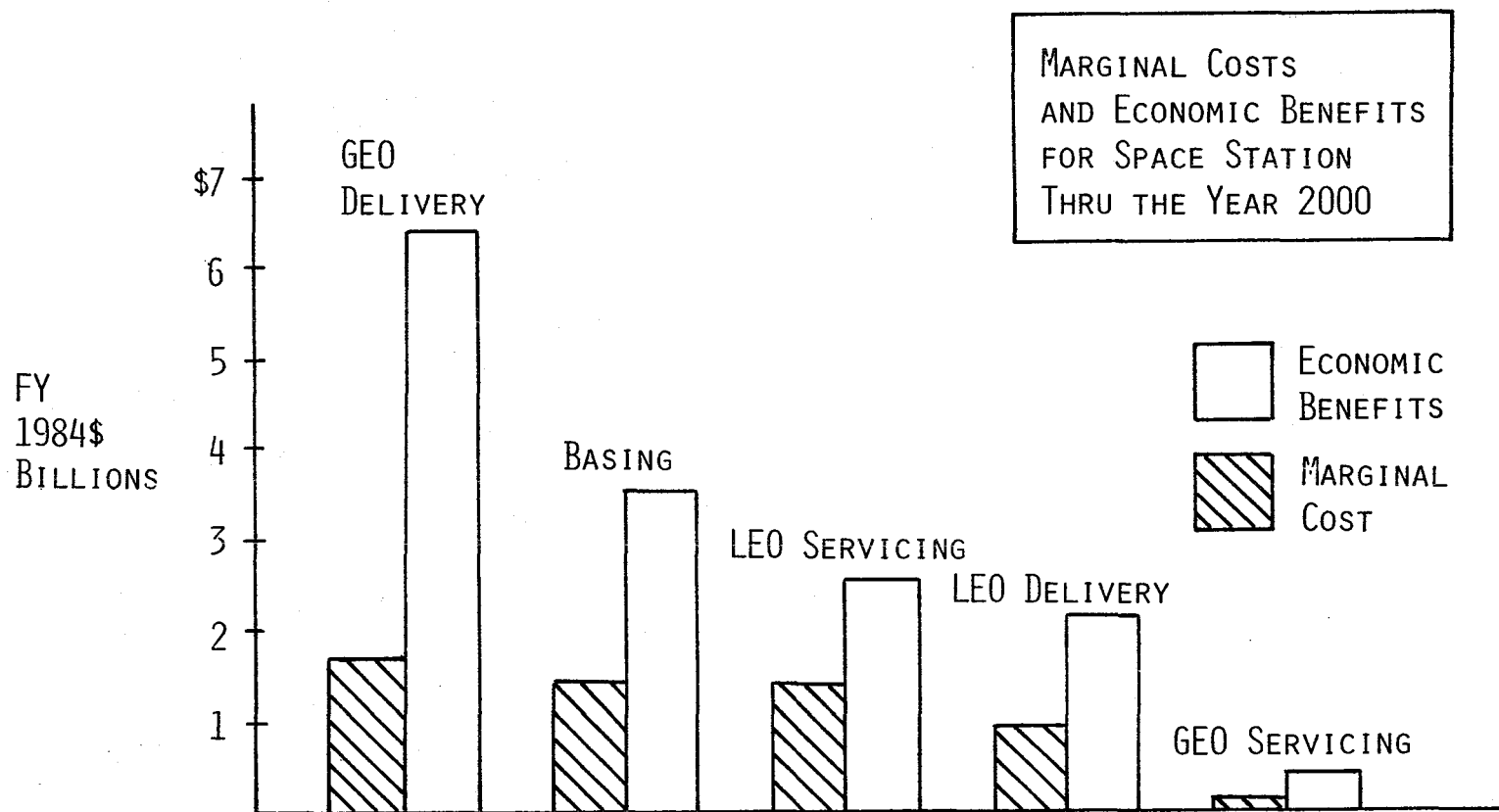
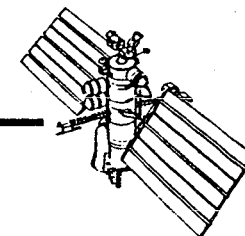


Development Cost Drivers
FY 1984 \$ Millions

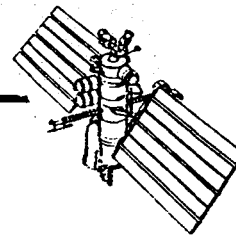
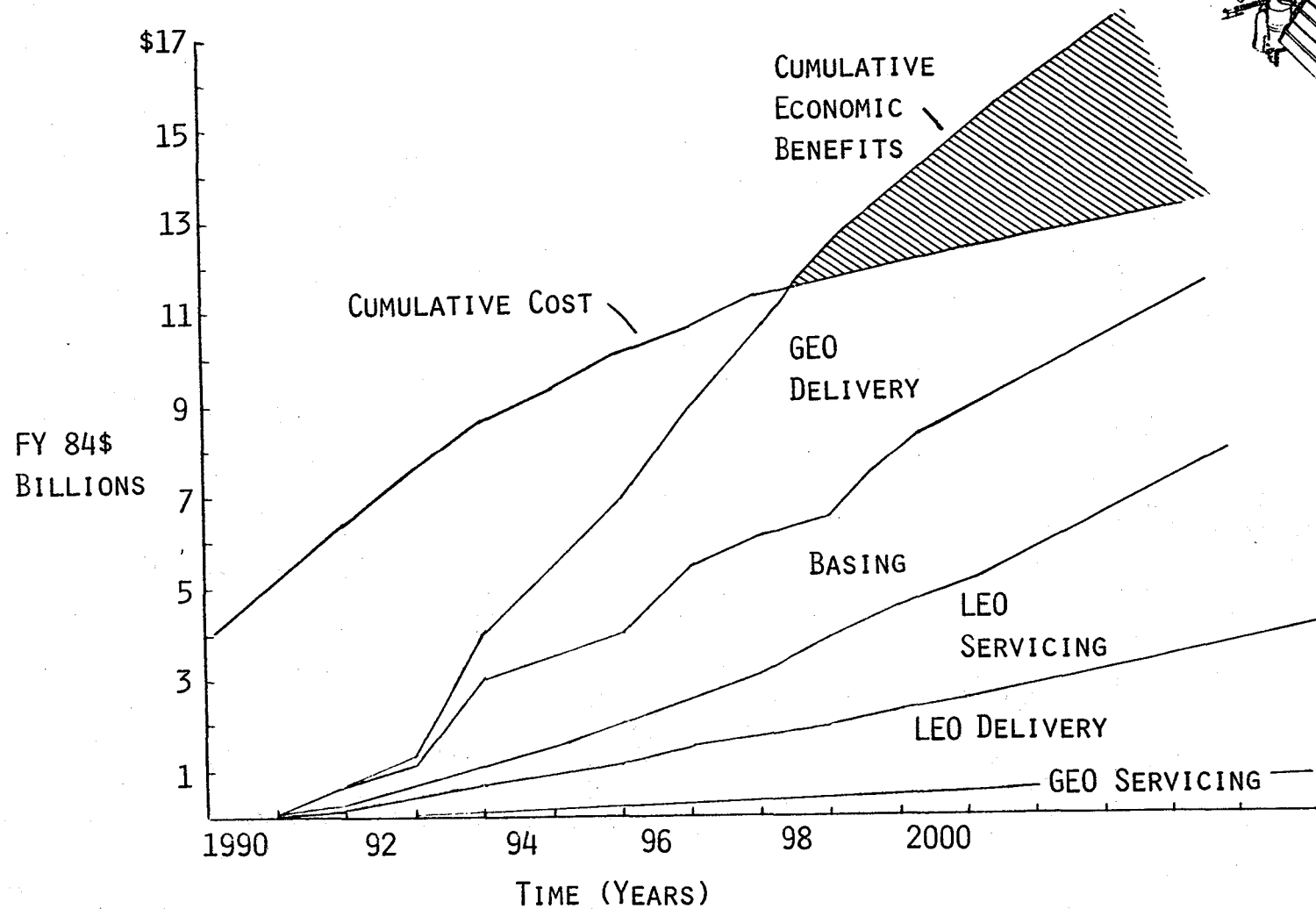


Unit Production Cost Drivers
FY 1984 \$ Millions

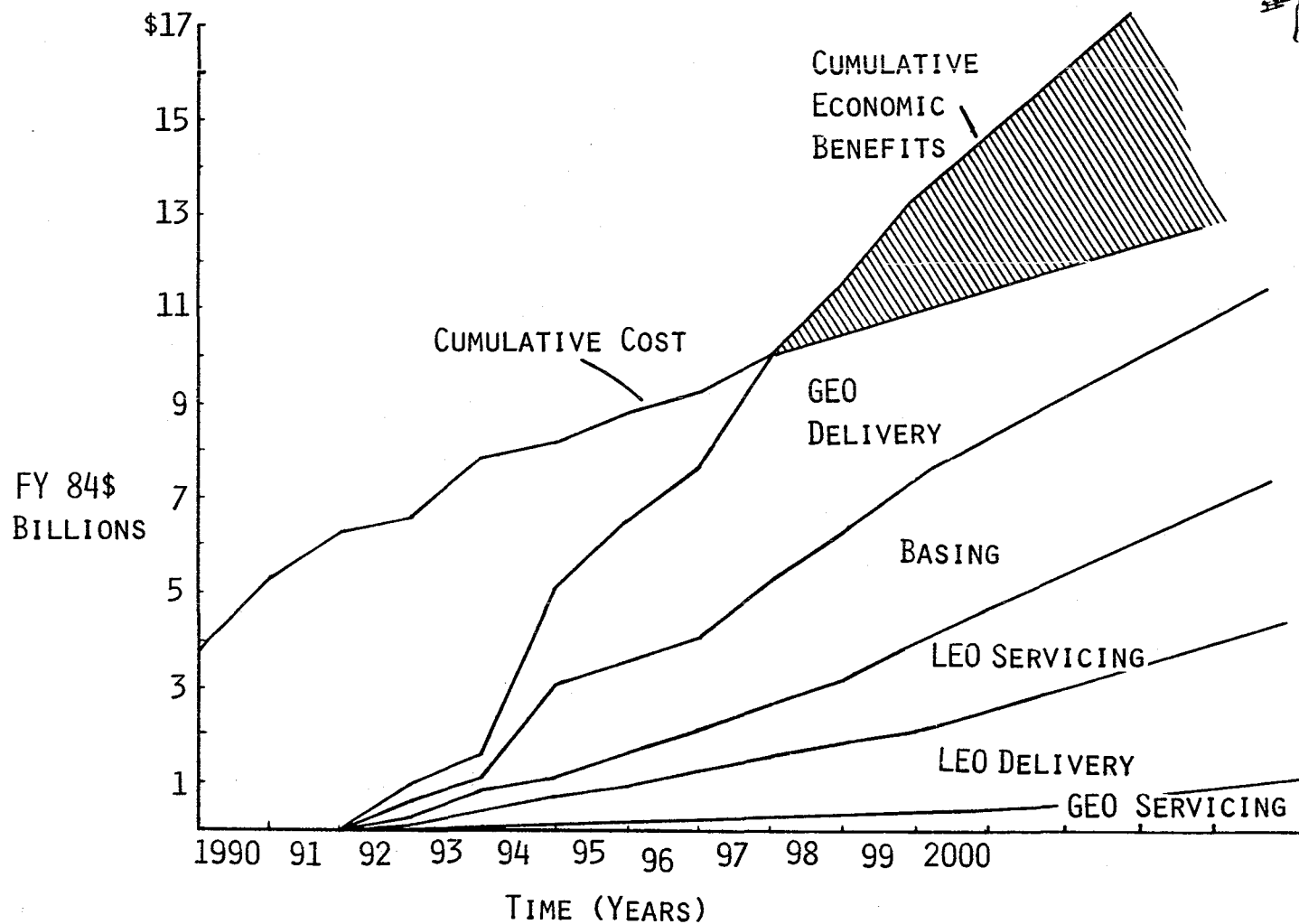
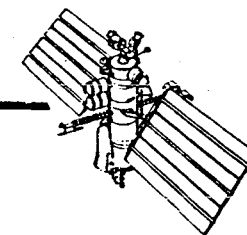
Marginal Costs And Economic Benefits By Capability Increment



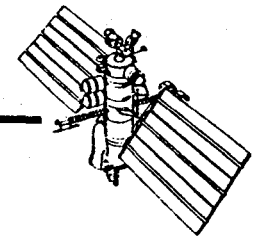
Cost/Benefit Breakeven Analysis – Modular Space Station 28.5°



Cost/Benefit Breakeven Analysis – SDV Space Station 28.5°



Space Station Benefits Summary



ECONOMIC

IN 10 YEARS OF OPERATION SPACE STATION PROVIDES:

- A SPACE TRANSPORTATION BASE THAT SAVES \$8.6B
- A SUBSYSTEMS UTILITIES BASE THAT SAVES \$3.6B
- A SPACE SERVICING CENTER THAT SAVES \$3.0B

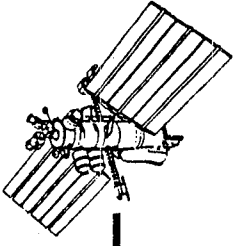
PERFORMANCE

SPACE STATION PROVIDES LONG TERM, UNIQUE CAPABILITY FOR:

- OBSERVATION
- MATERIALS PROCESSING RESEARCH
- LIFE SCIENCE RESEARCH
- REPAIR AND SERVICING
- LARGE VOLUME STRUCTURAL ASSEMBLY

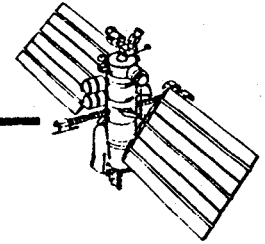
SOCIAL

- PROMOTES INTERNATIONAL COOPERATION IN SPACE SCIENCE, RESEARCH AND TECHNOLOGY
- MAINTAINS NATIONAL TECHNOLOGY ADVANCEMENT AND SPACE LEADERSHIP



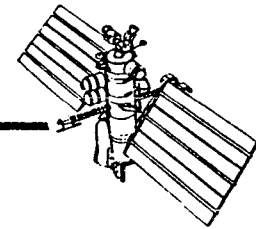
Conclusions

Summary Conclusions

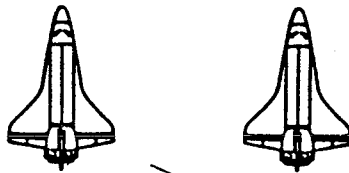


- SPACE STATION SYSTEM PROVIDES BOTH ECONOMIC AND PERFORMANCE BENEFITS
- SPACE STATION SYSTEM IS AFFORDABLE WITHIN PROJECTED NASA BUDGET CONSTRAINTS:
 - ACQUISITION OF SPACE STATION SYSTEM
 - EXPANDED SCIENCE AND APPLICATIONS PROGRAMS
- STS SUPPORT REQUIRED BY SPACE STATION IS WITHIN CURRENT FLEET CAPABILITIES
- EARLY MANNED PRESENCE IN LEO STATION IS JUSTIFIED:
 - TO SATISFY EXISTING USER REQUIREMENTS
 - MAXIMIZE PERFORMANCE AND ECONOMIC BENEFITS
 - PERFORM COMPLEX AND UNIQUE ASSEMBLY, C/O AND MAINTENANCE OPERATIONS

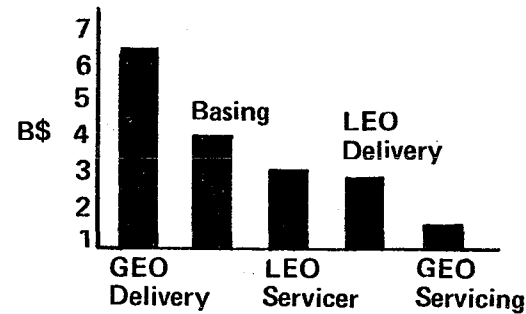
Space Station Payoffs



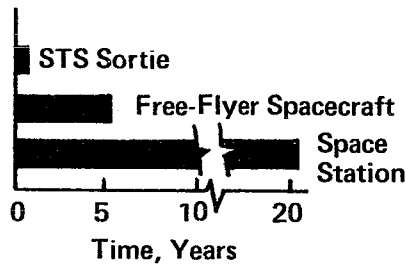
Equivalent to Two Additional Orbiters



Provides Significant Economic Benefit as Launch and Utilities Base

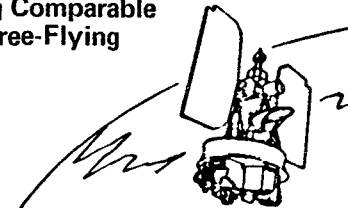


Extended Time Onorbit

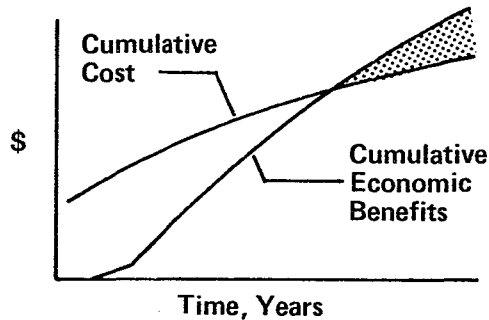


**SPACE STATION
A
CAPABILITY
MULTIPLIER**

Provides Basing Comparable to Dozens of Free-Flying Spacecraft



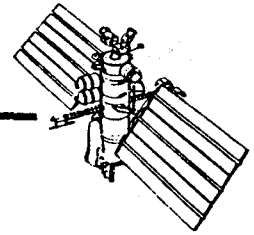
Benefits Exceed Cost Within Lifetime of System



Provides Long-Term, Unique Capability for

- Observation
- Materials Processing Research
- Life Science Research
- Repair & Servicing
- Large Volume Structural Assembly

Summary Conclusions (Continued)



- SINGLE SPACE STATION AT 28.5° SUPPORTS 80% OF USER MISSIONS --
A SECOND STATION AT HIGH INCLINATION CAPTURES AN ADDITIONAL
5% OF THE USERS AT A 50% INCREASE IN COST

- EARLY SPACE STATION ARCHITECTURE SHOULD INCLUDE:
 - REUSABLE OTV WITH AEROBRAKING
 - TMS WITH TELEPRESENCE SERVICER
 - OTV/TMS REFUELING AND SERVICING CAPABILITY
 - ATTACHED RESEARCH LABORATORIES
(LIFE SCI. & MTLs PROC.)

End of Document